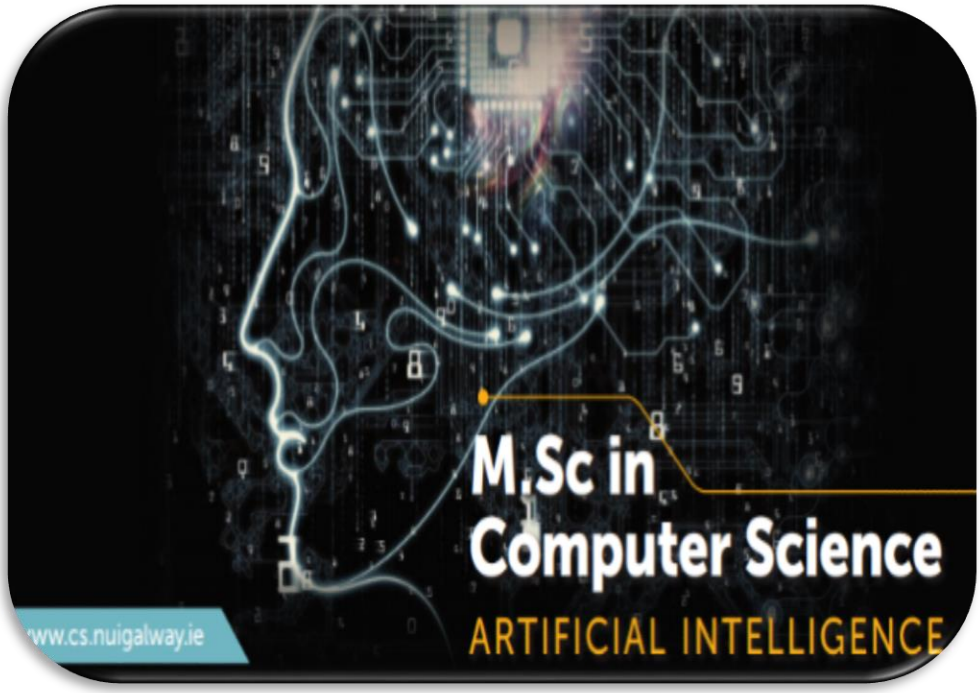
School of Computer Science
College of Science and Engineering



STUDENT HANDBOOK

2020 | 2021

NUI Galway School of Computer Science requires all students to have exclusive use of a laptop for use in lectures and labs, for home use of online materials and for participation in online sessions.

The minimum and recommend spec are detailed at http://www.nuigalway.ie/science-engineering/school-of-computer-science/currentstudents/laptops/.

We also operate a laptop loan scheme for students who cannot afford a suitable laptop (see same address).

Table of Contents

Please note: This handbook is for information only and is correct at time of compilation. However, processes and procedures may change throughout the academic year. Please contact the relevant websites and Administrative Offices for up to date information.

Section 1: Programme Descriptions

1.1 M.Sc in Computer Science – Artificial Intelligence

The M.Sc. in Computer Science - Artificial Intelligence is a 1-year 90-ECTS course with three main elements:

- Foundational modules (35 ECTS)
- Advanced modules (25 ECTS), and
- A substantial capstone project (30 ECTS).

Foundational modules include:
Machine Learning and Deep Learning; Natural Language Processing; Information Retrieval; Meta-Heuristic Optimisation; Ethics in Artificial Intelligence; Autonomous Agents and Multi-Agent Systems.

Advanced modules include:
Programming and Tools for AI; Knowledge Representation & Statistical Relational Learning; Data Visualisation; Programming for Data Analytics; Web & Network Science; Embedded Image Processing; Tools and Techniques for Large Scale Data Analytics; Research Topics in AI.

From semester II onwards, students work on individual projects and submit them in August. Projects may have a research or applied focus.

Career Opportunities
Graduates will be excellently qualified to pursue new careers in Artificial Intelligence; such careers may include R&D opportunities in industry, PhD-level research, or the establishment of new ventures that provide leading-edge AI solutions and products.

Section 2: General Information

2.1 Academic Calendar 2020-2021

http://www.nuigalway.ie/academic_dates/academic_term_dates.html

Academic Year 2020-2021	
Semester 1	
Start of Teaching (UG years (excluding Year 1) and Postgraduate Taught programmes)	Monday 28th September 2020
End of Teaching all years	18th December 2020
Semester 1 Exams	11th – 22nd January 2021
Semester 2	
Teaching (All Years, UG & PGT)	Monday 8th February 2021 – Friday 2nd April 2021
Easter	**Good Friday 2nd April -Easter Monday 5th April 2021**
Field Trips	Tuesday 6th April – Friday 9th April 2021
Teaching (All Years, UG & PGT)	Monday 12th April – Friday 7th May 2021
Semester 2 Exams	18th May – 4th June 2021
Easter Holidays: Good Friday 2nd April to Easter Monday 5th April 2021 **Bank holidays: Monday 26th October 2020 / Wednesday 17th March 2021 / Monday 3rd May 2021 / Monday 7th June 2021 / Monday 2nd August 2021**	

2.2 Key Contact Details

Programme Director

Programme	Programme Director	Room	E:mail
M.Sc in Computer Science – Artificial Intelligence	Dr Michael Schukat	442	Michael.schukat@nuigalway.ie

Technical and Administrative Staff

Administrative Staff		Room	E:mail
Ms. Mary Hardiman		414	Mary.hardiman@nuigalway.ie
IT Technical Staff			
Mr Peter O'Kane		435	Peter.okane@nuigalway.ie
Mr John Hynes		420	John.hynes@nuigalway.ie
Mr Joe O'Connell		434	Joe.oconnell@nuigalway.ie

The School of Computer Science is located in the IT Building, Floor 3.

For directions to the IT Building please click here.

Student Contact Centre
The Student Contact Centre (tel: (091) 495999) provides the following services and is located on the ground floor of Áras Uí Chathail, which is situated on the main campus:

- Registration, Exams and Admissions queries
- Prospectus pick up
- Replacement ID Cards
- Transcript Requests
- Validation and stamping of forms e.g. social welfare, medical card, drug payment,
- USIT visa (Student Travelcard forms are stamped by SU)
- Change of Name/ Change of Address requests
- Statements e.g. letters of attendance

Useful Contact Numbers (http://www.nuigalway.ie/about-us/contact-us/)

Student Information Desk	(091) 495999
ISS Help Desk	(091) 495777
Admissions Office	(091) 495999
Accommodation Office	(091) 492760
Disability Liaison Office	(091) 492813
Fees Office	(091) 492386
Health & Safety Office	(091) 492678
Campus Security / Emergency	(091) 493333
Student Counselling	(091) 492484
Student Health Unit	(091) 492604
Students Union Shop	(091) 492411
General Emergency	999
Local Garda Station	(091) 538 000
Hospital (UCHG)	(091) 580580
Samaritans	(091) 561222

2.3 Maps

NUI Galway Campus map can be located on the University's website at:
http://www.ptba.nuigalway.ie/images/campus_map_.pdf
http://www.nuigalway.ie/media/internationalstudents/files/Campus-Map-Sept-2014.pdf

2.4 Examinations

The Examinations Office posts all results to the home address of each candidate. It is the responsibility of students to inform the **Admissions Office** of any change of address.

Results

Results will **NOT** be given on the telephone to candidates, or to anyone acting on their behalf.

Examination Timetables

Examination timetables may be viewed on the NUI, Galway web page at the following address: http://www.nuigalway.ie/exams/timetable-advice/examtimetable/. Personalised timetables will be available on the WEB on a date to be advised by the Exams Office.

Timetables will NOT be posted to students.

Please be advised:

- Check the timetable OFTEN as changes may occur
- Revisions to timetable will be published on the Examinations Office WEB page only
- Revisions to timetable will not be posted to individuals

Repeat, Appeals and Re-checks

Appeals and rechecks should be addressed to the Examinations Office. In the case of Appeals, candidates must first consult the Head of the College of Engineering & Informatics for advice. A fee must be lodged with both the Appeal and Recheck Forms. Appeals from summer examinations must be lodged within four weeks after the issue of results (and up to three weeks after the issue of results in autumn where). Rechecks must be lodged up to three weeks after the issue of summer examination results. Fees are refunded if the outcome is positive.

Exam Board Sittings

The examinations board will sit in June and October where relevant examination, project and theses grades will be processed by the College of Engineering & Informatics.

Deferral of Exams

A guide for exam deferrals is available at http://www.nuigalway.ie/exams/timetable-advice/deferrals/. This guide is to assist students with the process and provides a link to the application form and guidelines.

2.5 Student Services

Coming to University is a major milestone in your life and a point of changeover in your life. You are facing into some challenges and many opportunities. You will encounter the enjoyment and challenges of independence and decision-making and responsibility for your own well-being and lifestyle.

Student Services is a team that are core to the personal and academic development of students. Student Services is under the management of the Vice President for the Student Experience. Student Services is committed to enhancing the individual student experience by providing an excellent service which supports the holistic development of the person, thereby enabling each student to achieve their full academic potential. Through valuing, recognising and supporting each staff member and by forging strong alliances within the University Community, Student Services will assist NUI Galway to become a truly Student Centred University.

Student Services provides support as follows:

- Personal Support: Accommodation, Chaplaincy, Counselling, Disability Support, Mature Students office, Health Unit, Student Connect Mentoring Programme.
- Career and Professional Support; Job Search; Postgraduate Study & Student Abroad, Career and occupation information, Work Experience (PEP and GEP).
- Social and Recreational Opportunities; Sport Facilities, 40 Sports Clubs, 77 Societies and Sports Centre.

Detailed information on all the Student Services offered by NUI Galway may be found at http://www.nuigalway.ie/student-life/student-support/

Student Services Staff

Mr. John Hannon
Director
Aras Uí Cathail
Tel: 091-493586 ext. 3586
E-mail: john.hannon@nuigalway.ie

Ms. Teresa Kelly
Administrative Assistant
Aras Uí Cathail
Tel. 091-492364 ext. 2364
E-mail: Teresa.Kelly@nuigalway.ie

Ms. Una McDermott
Administrative Assistant
Aras Uí Cathail
Tel: 091-495282 ext. 5282
E-mail: Una.McDermott@nuigalway.ie

Ms. Angela Walsh
Administrative Assistant
Aras Uí Cathail
Tel: 091-493540 ext. 2364
E-mail: Angela.Walsh@nuigalway.ie

2.6 International Students

All international students are strongly encouraged to attend English for Academic Purposes (EAP) classes which are specifically designed to equip international students with specific English skills to help them with their studies. Please refer to http://www.nuigalway.ie/international-students/ for more details.

The International Office provide advice, information and support service for all International Students. For incoming international students information is available on http://www.nuigalway.ie/international/covid-19/.

The International Student Officer, Ms. Louise Kelly may be contacted at International Office, National University of Ireland, Galway. Tel 353 91 493581, E-mail: louise.kelly@nuigalway.ie. Ms. Kelly acts as an identifiable point of contact with the various Student Services in the University to ensure that any problems of adjustment are minimised. She helps International Students adjust as quickly as possible to their new environment, so that they can derive maximum benefit and enjoyment from their life at NUI Galway.

2.7 Computer Science Account and Swipe Card Access to Labs

The School of Computer Science has a number of undergraduate and postgraduate rooms which are for the use of our own students. Within these rooms are computers and printers. All students who are taking a module/course with the School of CS are entitled to an account to access the open access labs in the IT Building (Note: IT 106 is available to all NUIG students using main NUIG account). Depending on their course they may also have swipe card access to further project labs in the IT Building.

Accounts are setup automatically after a student registers for one of our modules/courses, and students will receive an email to their NUIG email to indicate the account is ready for use. Students must then log on to a URL to retrieve their password: http://www2.it.nuigalway.ie/accounts/. This will give the password, weekly print quota and list any swipe card access to rooms. Students who have issues with their Computer Science computer account, a PC or swipe access in the IT Building should log a call to Computer Science Technical officers: support@it.nuigalway.ie.

Useful link for further related info: http://www.cs.nuigalway.ie/currentstudents/. Students who have issues with their main NUIG account, Wifi, Blackboard, personal laptops or any PC/printer on the rest of campus should refer to the NUIG helpdesk: http://www.nuigalway.ie/information-solutions-services/services-for-students/

2.8 DISC - Computer Programming Drop-In Support Centre

Computer DISC is a Computer Programming Drop-In Support Centre for all NUI Galway students who are taking any programming/software development courses. The DISC is a free service that supports all students with their self-directed learning in computing topics at all years and levels in NUI Galway. The centre is located in Room 205 on 1st floor of the Information Technology (IT) Building.

What services does Computer DISC provide to students?

- Facilities for students to sit and work on programming problems
- One-to-one advice and support for students, and focused small group tutorials
- Books, courseware, web links, and other learning resources for programming students
- A website with information and an email service for all queries
- Advice for students who wish to learn new programming languages autonomously
- Assistance with new technologies for project work such as Final Year Projects

2.9 Student Counselling

The counselling service is part of a network of support services offered by NUI, Galway. It provides professional counselling, which is **free** and **confidential** to all students of NUI, Galway. Life as a student is exciting and challenging, an achievement usually gained after much hard work and preparation. It can also be stressful at times. You may find you are experiencing personal difficulties which are affecting your ability to study and to take full advantage of the opportunities available to you at NUI, Galway. This is where we can help. We are a team of qualified and experienced counsellors, psychologists and psychotherapists. The service operates within the Code of Ethics and Practice agreed by the Irish Association of University and College Counsellors (IAUCC). The services provided include:

- Pre-counselling assessment
- Individual counselling and psychotherapy
- Group work
- Information and referral
- A consultation service for those who may have concerns about a student – such as tutors, university staff, friends or parents

A drop in service is open every weekday in term time from 2.00pm to 4.00pm. Further information is available http://www.nuigalway.ie/counsellors/about-us/

Counselling Staff

Ms. Geraldine Connolly, Head of Counselling
Direct Tel**:** 091 – 495202, Ext. 5202
E-mail**:** geraldine.connolly@nuigalway.ie

Ms. Emer Casey, Counsellor
Direct Tel. 091 – 495633, Ext. 5633
E-mail: emer.casey@nuigalway.ie

Contact Address:
Counselling Services No. 5 Distillery Road NUI, Galway
Direct Tel**:** 091 492484 ext**.** 2484
E-mail**:** counselling@nuigalway.ie

2.10 Blackboard

Blackboard is the Virtual Learning Environment (VLE) in use at NUI Galway. Blackboard is a web based application that gives students access to all their courses at NUI Galway. Blackboard allows students to download lecture notes, reading lists, assessment information and other course-related material. Students have access to their online Blackboard courses once they have registered with NUI Galway. When a student registers for a course or module with the NUI Galway Student Records System, they are automatically enrolled in the corresponding course on Blackboard. These changes are recognised by Blackboard within 24 hours.

If students require additional assistance with their login, they should contact the Service Desk within Information Solutions and Services (ISS). ISS can assist students with queries they may have relating to Blackboard including logging in to Blackboard or queries relating to their password or e-mail account. If students are unable to see courses when they log into Blackboard, they will need to check their registration statement to ensure they are correctly registered.

Students who are not registered, will need to contact Admissions or the Student Contact Centre on the ground floor of Áras Uí Chathail to process their registration details prior to gaining access to Blackboard.

2.11 Plagiarism

Plagiarism refers to copying another author's work without due reference or acknowledgement of the author. Plagiarism is not acceptable. It is essential that the candidate acknowledge other people's work, when used by the student. The submitted work must be prepared by the candidate alone, and must be the result of the candidate's own effort, skills and knowledge. It is unacceptable for candidates to knowingly permit others to copy their work. NUI, Galway has a strict code of practice for dealing with plagiarism, please visit the following site for more details – http://www.nuigalway.ie/plagiarism/

2.12 Information Solutions and Services (ISS)

ISS aim to provide students with access to the ICT facilities which they need to succeed in their studies at NUI Galway. These facilities include high speed Internet access, an NUI Galway email account, and access to the resources of the James Hardiman Library and the Blackboard virtual learning environment. These services are accessible from the on-campus PC suites and from suitably equipped laptops using the on-campus wireless network. A Campus Account (CASS) provides students access using a single User ID and Password to all computing services, other than E-mail. Students should refer to their Registration Guide for their temporary activation password. To activate your Campus Account, student need to go one to https://cass.nuigalway.ie/ and login using their current student ID number and the activation password.

ISS Service Desk (Service Desk is located in the foyer of the James Hardiman Library).
E-mail address: servicedesk@nuigalway.ie
Direct Phone: 091 495777. Extension: 5777

2.13 Career Development Centre

The Career Development Centre is focused on facilitating and empowering students of NUI, Galway to manage their own career development and empowering students to make successful transitions towards fulfilling careers. Careers send out weekly emails to students with upcoming events during term to all students.

Details of the services provided to students by the Career Development Centre include:

- finding out options with your degree
- getting information on careers
- finding out about further study
- finding out or applying for a job
- develop skills that employers want
- Internships and Work Experience Fair
- Professional Associations Expo.

The Careers Development Centre host workshops to help students with applications and job search. One-off sessions are also offered to students and are bookable through Careers Connect and include:

- CV workshops - held monthly during semester.
- Interview workshop - held once a semester.
- LinkedIn workshop - typically 3 per semester.
- Personal Statement workshop - held once a semester

Further information on the range of services provided by the Careers Development Centre can be found at: http://www.nuigalway.ie/career-development-centre/

Career Development Centre

Location: Arts/Science Building (1st Floor)
Tel: +353 (0)91 493589

2.14 Out of Hours Working

Out of hours work refers to all University operations conducted outside normal hours. There are two relevant time-scales:

- **5.30pm – 11pm (week-days) and 8am – 11pm (weekends)**
  When University buildings are accessible and while not in full operation, there may still be many people on site.

- **11pm – 8am (week-days and weekends)**
  When University buildings are locked by Security and therefore only accessible to personnel with keys.
  All such out of hours working are high risk because:
  - Fewer staff and students are on-site to raise the alarm and/or give assistance in the event of an accident of incident
  - Modified emergency measures may apply
  - Personnel may be working alone

The listed below are the controls/arrangements to be used in reducing the risk of out of hours working:

- Out of hours working must be eliminated as much as possible. In particular high hazard work, or work/study by inexperienced persons, e.g. undergraduate students, **MUST** be restricted to normal University hours, when they can be appropriately supervised
- Hazardous work, e.g. laboratory operations, must be planned in advance to eliminate the hazardous procedures that need to be conducted out of hours*. Any work, which must be carried out outside normal working hours, must be conducted in pairs (buddy-system) or with a colleague within easy calling distance
- Persons working out of hours must receive written permission from the Head of department/section. This permission must be restricted to personnel who can justify the requirement to work out of hours
- A register of late night work is to be maintained by Security. This will be made up from the lists of those personnel authorized to work late, submitted by the Head of the department/section. Any personnel not listed and found in the department/section after 11pm will be requested to leave by Security. Where a later finishing time has been approved by a Head of department/section, this will be made known to Security and treated as the final finishing time
- Ensure necessary emergency equipment/measures are available and made know to persons working out of hours, e.g. which emergency escapes are available, accessible phones with outside lines for emergency phone contact
- *Operations/experiments – if left running without supervision, must be as safe as possible in advance, and should be identified by an Unattended Experiment Form. The Safety Health and Welfare at Work (Night work and Shift work) Regulations 2000 S.I 11 of 2000 must also be complied with, when and where applicable

2.15 Parking on Campus

Parking spaces in NUI, Galway fall into a number of categories:

- Staff Only
- Student Only
- Pay and Display (P&D) spaces
- "Reserved" spaces and loading bays

The parking permit payment system can be accessed via the Buildings Office website at http://www.nuigalway.ie/buildings/parking.html. Please note that you will be required to login, using your normal NUI Galway username/password authentication.

To purchase/renew your Student Parking Permit please log on to https://permits.apcoa.ie/.

If you park in a "Pay and Display" space, you must display a valid Pay & Display ticket and park only in spaces marked "Pay and Display". Should you have any queries, please consult our *Frequently Asked Questions* on http://www.nuigalway.ie/buildings/faq.html

A park and ride service operates from Dangan car park. Further information and timetable details are available from
http://www.nuigalway.ie/buildings/documents/park_and_ride_timetable

Parking Office Location: Room 103A, Ground Floor Arts Millennium Building
Opening Hours: Monday to Friday, 0930 - 1200 and 1400 - 1600

Contacts:
Email: parking@nuigalway.ie
Tel. 353 91 495063 (ext. 5063)

2.16 Registration

Online registration opens on Tuesday 15th September for postgraduate taught students. Details of relevant dates can be found on: (http://www.nuigalway.ie/registration/quick-links/registration-dates/). Students will receive an email from registration before Online Registration opens inviting students to register online. Students should register as soon as possible for their programme to gain access to University services such as Student ID Card, Library, Blackboard, etc. Further registration details can be found on: http://www.nuigalway.ie/registration/reghelp_home.html/newstudentpostgrad/

2.17 Library

The Student ID card also acts as a Library card. Students must have a current card in order to gain entrance to the Library. Details on the services provided by the library are available at http://library.nuigalway.ie/usingthelibrary/accessingthelibrary/ The Library and IT Service Desk is located on the ground floor of the library and provides advice and support to students on both Library and IT services (e.g., User ID/passwords, book loans, printing Wifi access).

2.18 Module Descriptions

Modules – Semester I:

1MA1	Modules	
Core	CT4101 Machine Learning (formerly module code CT475 Machine Learning and Data Mining)	Credits: 5
Core	CT5120 Introduction to Natural Language Processing	Credits: 5
Core	CT5132 Programming for Tools for AI	Credits: 5
Core	CT5142 Artificial Intelligence and Ethics	Credits: 5
Core	CT4100 Information Retrieval (formerly module code CT422 Modern Information Management)	Credits: 5
Core	CT5141 Optimisation	Credits: 5
Optional	EE445 Digital Signal Processing	Credits: 5
Optional	CT561 Systems Modelling and Simulation	Credits: 5
Optional	CT5105 Tools & Techniques for Large Scale DA	Credits: 5

Note: In the event that students have previously taken one of these module as a NUI Galway student, then you cannot enroll again in a module that you have previously been awarded credits for. Students that are affected can select from the other optional modules offered on the syllabus.

CT4101: Machine Learning (formerly module code CT475 Machine Learning and Data Mining)

Definitions of Machine Learning, Data Mining and the relationship between them; the CRISP Data Mining process model; major tasks including classification, regression, clustering, association learning, feature selection, and reinforcement learning; algorithms for these tasks that may include decision tree learning, instance-based learning, probabilistic learning, support vector machines, linear and logistic regression, and Q-learning; open-source software tools for data mining; practical applications such as sensor data analysis, healthcare data analysis, and text mining to identify spam email; ethical issues and emerging trends in data mining and machine learning.

CT5120: Introduction to Natural Language Processing

Introduction to natural language processing, including foundations in linguistics, statistical analysis and applications.

CT5132 Programming and Tools for AI

This module is about programming and computational tools required for artificial intelligence. It uses the Python language as the main vehicle, but focusses on conceptual material rather than just the language itself. It moves fast through introductory Python workings. It covers several important Python libraries in detail. It discusses approaches to building re-usable, high quality code but not on software engineering. It also visits some extra topics such as version control and an introduction to the R language for statistics. The module is core for the NUI Galway MSc in Artificial Intelligence (MScAI) Part-time (online) and Full-time (classroom). The syllabus and assessment will be the same for both. We will use a hybrid of lecture-style and lab-style delivery. The lecture-style delivery will be via video (for the part-time/online version) or classroom (for the full-time version). Practical exercises will be interleaved with the lecture-style delivery. This module will be divided into the following main topics:

1. Weeks 1-2: Introductory Python: writing and executing Python code through an IDE, command line, or notebook; arithmetic; syntax; comments and doc-strings; variables; functions; loops and conditionals; lists, tuples, dictionaries; classes; input/output; version control.
2. Weeks 3-4: Python data libraries: Numpy, Pandas, Matplotlib, and friends.
3. Weeks 5-6: Introductory R: some side-by-side comparisons between R and Python; R for statistics.
4. Weeks 7-11: Python software for AI: Scikit-learn API (but not details of the algorithms themselves), NetworkX, and many examples.
5. Week 12: Testing, notebooks, cloud execution.

We will use up-to-date versions of software, and in particular we will use Python 3 (not Python 2).

CT5142 Artificial Intelligence and Ethics

Artificial intelligence technologies have evolved dramatically in recent years, impacting on many areas of human life. Societal responses to these developments have ranged from enthusiastic optimism to deep suspicion. The module will explore prominent ethical issues arising in relation to the design, use and societal impact of Artificial Intelligence. Topics addressed in the module include Philosophy of Technology, Value Sensitive Design,

Responsible Research and Innovation (RRI), Privacy and consent, Contextual integrity, Transparency and explainable AI, Trust and Trustworthiness, Datafication, Algorithmic surveillance, Algorithmic Bias, Autonomous artificial agents and responsibility, and Human replacement.

CT4100: Information Retrieval (formerly module code CT422 Modern Information Management)

The course introduces some of the main theories and techniques in the domain of information retrieval.

CT5141 Optimisation

This module covers optimisation -- "the science of better". Optimisation is used in a huge variety of applications, including: finding time-saving transport routes; scheduling exams without conflicts; reducing weight and cost in engineering design; designing portfolios of financial investments; finding numerical data models with low expected error; and many more. In this module we will aim to understanding a broad range of applications and a unifying view of the field, and concentrate on two main types of methods: (1) metaheuristic optimisation and (2) exact methods for constrained optimisation. In this module we will not cover gradient descent and related methods, as they are covered in machine learning modules available on the MScAI. We will spend time in-class on practical implementations, writing our own optimisation programs from scratch and also using state-of-the-art libraries.

CT5105 Tools & Techniques for Large Scale DA

Large-scale data analytics is concerned with the processing and analysis of large quantities of data, typically from distributed sources (such as data streams on the internet). This module introduces students to state-of-the-art approaches to large-scale data analytics. Students learn about foundational concepts, software tools and advanced programming techniques for the scalable storage, processing and predictive analysis of high- volume and high-velocity data, and how to apply them to practical problems. This module uses Java as programming language. Knowledge of Java is a prerequisite for participation in this module. Planned topics include: Definition of large-scale computational data analytics; Overview of approaches to the processing and analysis of high volume and high velocity data from distributed sources; Applications of large-scale data analytics; Foundations of cluster

computing and parallel data processing; The Hadoop and Spark ecosystems. MapReduce; Advanced programming concepts for large-scale data analytics; Concepts and tools for large-scale data storage; Stream data analytics. Complex Event Processing (CEP); Techniques and open-source tools for large-scale predictive analytics; Computational statistics and machine learning with large-scale data processing frameworks such as Spark; Privacy in the context of large-scale data analytics.

EE445 Digital Signal Processing

Syllabus Outline: Discrete-time systems, time-domain analysis. The z-Transform. Frequency-domain analysis, the Fourier Transform. Digital filter structures and implementation. Spectral analysis with the DFT, practical considerations. Digital filter design: IIR, FIR, window methods, use of analogue prototypes.

CT561 Systems Modelling and Simulation

Simulation is a quantitative method used to support decision making and predicting system behaviour over time. This course focuses the system dynamics approach. The course covers the fundamentals of simulation, and describes how to design and build mathematical models. Case studies used include: software project management, public health policy planning, and capacity planning.

Modules – Semester II:

1MA1	Modules	
Core	CT5100 Data Visualisation	Credits: 5
Core	CT5133 Deep Learning	Credits: 5
Core	CT5134 Agents, Multi-Agent Systems and Reinforcement Learning	Credits: 5
Core	CT5135 Research Topics in AI	Credits: 5
Optional	CT5113 Web and Network Science	Credits: 5
Optional	EE551 Embedded Image Processing	Credits: 5
Optional	CT5121 Advanced Topics in NLP	Credits: 5
Optional	CT5137 Knowledge Representation & Statistical Relationship	Credits: 5

Note: In the event that students have previously taken one of these module as a NUI Galway student, then you cannot enroll again in a module that you have previously been awarded credits for. Students that are affected can select from the other optional modules offered on the syllabus.

CT5100: Data Visualisation

This module with teach the fundamentals of data visualization. It will cover basic design principles and the principles underlying human perception, color theory and narrative. It will focus on the use of open standards for the presentation of data on the Web such as HTML, CSS, SVG, JavaScript through the use of libraries such as D3.js, jQuery.js and Dimple.js.

CT5133: Deep Learning

This is an advanced module in machine learning, focusing on neural networks (NNs), deep NNs, and connectionist computing. Students learn about the basic principles and building blocks of deep learning, and how to implement a deep neural network 'from scratch'. They also learning about software libraries and tools, and gain experience of applying deep learning in a range of practical applications. The module includes substantial practical programming assignments.

CT5134 Agents, Multi-Agents Systems and Reinforcement

The topic of Agents and Multi-Agent Systems, examines environment that involve autonomous decision making software actors to interact with their surroundings with the aim of achieving some individual or overall goal. A typical agent environment could be a trading environment where an agent attempts to optimise energy usage, or the profitability of a transaction. More recently, significant global attention has focussed on the vision of autonomous vehicles, which also follows the core principle of an agent attempting to achieve a set of defined goals.

This module begins by examining the underpinnings of what is an Agent, and how we can better understand the principles of an agent and its autonomy. Multi-Agent Systems are then explored, as a means of understanding how many agents can interact with each other in a complex environment. Agents are commonly modelled using Game Theory, and in this module a range of Game Theoretic Models will be studied.

The module will examine Adaptive Learning Agents through the use of Reinforcement Learning algorithms an area of Machine Learning, which focuses on training learners to choose actions which yield the maximum reward in the absence of prior knowledge. The module takes a hands-on, practical approach to reinforcement learning theory, beginning with Markov Decision Processes, detailing practical learning examples in discrete environments and how to formulate a reinforcement learning task. It then extends this to continuous problem spaces, detailing Deep Reinforcement Learning with a practical implementation of a Deep Q Network using Keras.

CT5135 Research Topics in AI

In-depth study of two topical research areas.

CT5113: Web and Network Science

This module will provide the student with the skills to extract, clean and analyse data from the Web. The focus will be graph and network analytic approaches to Web-mining. Topics include: graph theory, network modelling, social network analysis, community-finding techniques, models of information diffusion, link prediction, evaluation techniques. There will be practical sessions on using graph-data bases and graph visualisation tools such as

Gephi. The student will learn how to apply Web mining techniques to applications such as recommender systems, adaptive personalisation, authority ranking.

EE551: Embedded Image Processing

This module provides and introductory course in digital signal analysis covering topics such as Discrete-time systems, time-domain analysis. The z-Transform. Frequency-domain analysis, Discrete Fourier Transform (DFT). Digital filter structures and implementation. Spectral analysis with the DFT, practical considerations. Digital filter design: IIR, FIR, window methods, use of analogue prototypes.

CT5121: Advanced Topics in Natural Language Processing

Advanced topics in natural language processing, including deep learning for NLP, machine translation and language resources.

CT5137 Knowledge Representation & Statistical Relationship

This module introduces students to formal Knowledge Representation and Statistical Relational Learning. Knowledge representation and reasoning are concerned with the efficient formal representation of information and its utilization for automated problem-solving tasks. Statistical Relational Learning is an area of Artificial Intelligence and Machine Learning concerned with the representation of, and reasoning and learning with, uncertain (probabilistic) and relational domain knowledge (such as graphs, web links or symbolic facts). Planned topics: Foundations of knowledge representation. Propositional and first-order logic. Foundations of reasoning (deductive, inductive, abductive, probabilistic). SAT and SMT. Logic programming. Probabilistic logics and uncertainty reasoning. Parameter and structure learning in statistical relational settings. Requirements: Existing basic knowledge of some logic or logic programming approach (such as propositional logic or Prolog) or Boolean algebra.