Universitat Oberta de Catalunya

uoc.edu

New Students Guide

Joint University Master's Degree in Computational and Mathematical Engineering (URV, UOC)

Next start date: October 2022

In collaboration with:

Universitat Rovira i Virgili

Contents

1. Presentation

The Joint University Master's Degree in Computational and Mathematical Engineering (URV, UOC) is an official online master's degree offering interdisciplinary training in the fields of engineering and applied sciences. The programme of study addresses many current topics, including computer modelling and simulation, numerical methods, parallel and distributed computing, networks and graphs, heuristic optimization, artificial intelligence, dynamic systems and big data.

The Master's Degree in Computational and Mathematical Engineering is a distance-learning programme co-organized by the **Universitat Rovira i Virgili (URV)** and the UOC. The URV is the **coordinating university**, meaning it handles enrolment and other academic procedures, while the UOC takes responsibility for teaching the online courses.

Its **primary goal** is to prepare students to take on RDI positions in industry or at a research centre, university or any other type of training facility. The online master's degree targets postgraduate students with a science or technology degree in Mathematics, Computer Engineering, Telecommunications Engineering, Statistics, Physics, etc. Students must complete a total of 60 ECTS credits, which are distributed as follows: 18 compulsory course credits, 24 optional course credits and 18 credits for the final master's degree project. The master's degree is designed so that students may complete it in one year (as full-time students) or in two years (as part-time students). The professors who teach on the degree are active researchers in their respective fields of study, which can encourage students to pursue a research career in computational and mathematical engineering.

The vehicular language for teaching the master is English, although communication in the classroom can be in Spanish, Catalan or English. Also, in communications with the teaching team and evaluations, students can use the language of their choice among the three. On the other hand, to take this master it is necessary to be able to read scientific-technical texts in English, since some teaching materials (books, articles, etc.) are exclusively in this language.

2. Enrolment and teaching information

Enrolment on the master's degree courses is carried out **annually** at the URV.
Teaching is done on the UOC's Virtual Campus over the course of one academic year, which is split into two **semesters**:

- From October to February
- From February to July

a) Admission and admission documents (URV)

https://www.urv.cat/en/studies/master/courses/computational-engineering/admission/

b) Enrolment for the 2022/23 academic year (URV)

Pre-enrolment and enrolment calendar

New students:

Phase 1.
Pre-enrolment: from 15 February to 15 April
Enrolment: from 11 to 20 July 2022

Phase 2.
Pre-enrolment: from 16 April to 31 May 2022
Enrolment: from 11 to 20 July 2022

Phase 3.

Pre-enrolment: from 1 June to 14 July 2022
Enrolment: from 8 to 30 September 2022

Phase 4.
Pre-enrolment: from 15 July to 9 September 2022
Enrolment: from 8 to 30 September 2022

Returning students (for whom pre-inscription is NOT necessary):

From 11 to 29 July and from 8 to 30 September 2022.

Pre-enrolment:
https://www.urv.cat/en/studies/master/admission/pas-a-pas-preinscripcio/

Enrolment:
https://www.urv.cat/en/studies/master/admission/registration/

Administrative procedures for master's degree students:
https://www.urv.cat/en/studies/master/administrative-procedures/

c) Teaching calendar for the 2022/23 academic year (UOC)

Semester 2022-1

→ Start date: October 2022
→ End date: February 2023

Semester 2022-2

→ Start date: February 2023
→ End date: July 2023

3. Programme of study

Courses and final master's degree project	No. of credits
Compulsory	18
Optional	24
Final Master's Degree Project	18
Total	**60**

All courses are worth 6 ECTS credits, except the one for the final master's degree, which is worth 18.

a) Courses by type

Compulsory courses	Optional courses (students choose four)
- Simulation - Numerical Methods in Engineering - High-Performance Computing - Final Master's Degree Project	- Artificial Intelligence - Large-Scale Distributed Systems - Operations Research - Template Matching - Data and Algorithm Structures - Metaheuristic Optimization - Data Analysis in Big Data Environments - Multivariate Data Analysis - Graph Theory and its Applications - Digital Codes - Cryptography and Blockchain Technology - Modelling through Differential Equations - Finite Elements and Finite Differences: Numerical Methods for PDEs - Complex Networks - Chaotic Dynamical Systems

b) Courses by semester

First semester courses	Second semester courses
- Digital Codes *(this semester is NOT offered)* - Finite Elements and Finite Differences: Numerical Methods for PDEs - Data and Algorithm Structures - Operations Research - Numerical Methods in Engineering - Modelling through Differential Equations - Metaheuristic Optimization - Simulation - Graph Theory and its Applications - Data Analysis in Big Data Environments	- Multivariate Data Analysis - High-Performance Computing - Cryptography and Blockchain Technology - Artificial Intelligence - Template Matching - Chaotic Dynamical Systems - Large-Scale Distributed Systems - Complex Networks
- Final Master's Degree Project	

c) Course information

- **Simulation**

Coordinating professor: Dr Javier Panadero
Type: Compulsory
Credits: 6 ECTS credits
Semester: First

Description: This course covers key concepts and equips students with the skills they need to model and simulate systems, networks and processes using Monte Carlo simulation (MCS) and discrete event simulation (DES) techniques. To this end, the course takes a theoretical and practical learning approach, covering modelling methods for data associated with random phenomena, pseudorandom number generation, simulation algorithm design, experimental design, verification and validation, results analysis and alternative design comparison. The course also provides training in specific modelling and simulation software (e.g. Simio) and teaches students to use it to study and solve practical cases from different fields of knowledge.

Requirements: Ability to read scientific texts in English. Basic knowledge of statistics (at an official *llicenciatura* or *enginyeria* degree level).

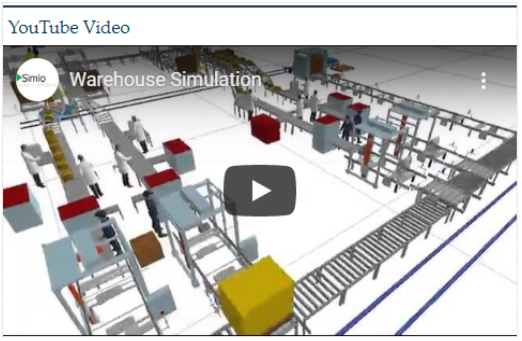
Bibliography: Robinson, S. (2004). *Simulation: The Practice of Model Development and Use*. Wiley.

Relevant software: Simio simulation software

Course plan

Links: Winter Simulation Conference (WSC) Archive

Related videos:



- **Numerical Methods in Engineering**

Coordinating professor: Dr Carme Olivé Farré / Dr. Gerard Fortuny / Dr. Jordi Villadelprat
Type: Compulsory
Credits: 6 ECTS credits
Semester: First

Description: Numerical methods play a key role in modern science. For instance, an aircraft's landing approach and the aerodynamic simulation of the behaviour of the air around it require the use of numerical methods. Likewise, many computer animation graphics are the result of applying these methods to render physical models. Interpolation, for example, allows animators to predict the intermediate positions between a body's initial and final state, and the movement of the clothing is rendered automatically as the numerical solution of differential equations. Errors in the solutions can then be treated to differentiate the error of the algorithm from the error caused by computers' finite accuracy. The course covers basic numerical methods and their application in engineering and science, as well as the analysis of the approximate solutions they provide.

Requirements: Ability to read technical and scientific documents in English. Basic knowledge of mathematics and programming (at an official *enginyeria* degree level).

Bibliography: Apuntes y Yangy, W.Y. (2005). "Applied Numerical Methods Using MATLAB".

Relevant software: MATLAB, Octave or Scilab. The UOC provides a licence to use MATLAB.

Course plan

- **High-Performance Computing**

Coordinating professor: Dr Josep Jorba
Type: Compulsory
Credits: 6 ECTS credits
Semester: Second

Description: This course covers key concepts and equips students with the skills they need to design and develop high-performance computing-based computational solutions as alternatives to traditional sequential systems. Students will learn about the process and communication design techniques required to develop applications that tap into the computational resources of current computing architectures. Finally, the course presents everything from classic algorithms to new architecture-aware optimized algorithms that enable higher computational performance.

Requirements: Basic knowledge of programming (C or Fortran) and user-level knowledge of GNU/Linus environments.

Relevant software: GNU Compiler Collection (C/C++/Fortran compiler) and GNU/Linux, Ubuntu and CentOS distributions.

Course plan

- **Data Analysis in Big Data Environments**

Coordinating professor: Dr Albert Solé Ribalta
Type: Optional
Credits: 6 ECTS credits
Semester: First

Description: This course serves as an introduction into the world of big data systems and technologies. It begins by taking an analytical look at the technology structures behind big data projects, including key aspects such as storage and distributed calculating systems and the management of cluster hardware resources. The course then moves on to the three main distributed processing models: batch processing, real-time or stream processing, and complex event processing. It also covers the main features and functions of today's most-used frameworks, with special attention given to the industry's top two standards: Apache Hadoop and Apache Spark. Finally, the course wraps up with a review of the main data analysis libraries, while addressing such topics as machine learning, graph analysis and big data visualization.

Requirements: Students are required to have prior programming experience (preferably in Python), as well as knowledge of data analysis, machine learning and computer networks. Moreover, as the course methodology expects students to resolve case studies and search for information on their own, they should be comfortable looking for information sources, analysing quantitative and qualitative data, synthesizing their findings, drawing conclusions and communicating via the written word. Some of the additional materials and resources are written in English, so students must also be able to read and understand this language.

Bibliography: Notes, books and scientific articles.

Course plan

- **Multivariate Data Analysis**

Coordinating professor: Dr Agusti Solanas
Type: Optional
Credits: 6 ECTS credits
Semester: Second

Description: This course is designed to offer students an integrated, in-depth look at and practical experience with multivariate data analysis. It aims to equip students with a set of research tools that will increase their ability to analyse and make sense of experimental data regarding systems, networks and processes, and to effectively lay out their results in scientific articles. The topics covered include multiple regression, analysis of variance and covariance (ANOVA and ANCOVA respectively), discriminant analysis, logistic regression, principal component analysis, factor analysis, cluster analysis, neural networks and big data analysis.

Requirements: Ability to read scientific texts in English. Basic knowledge of programming.

Bibliography: Notes, books and scientific articles.

Course plan

Related research group:

Name: Smart Technologies Research (formerly Smart Health)
Website: smarttechresearch.com

Description: Smart Technologies Research focuses on the use of information and communication technologies to create and apply contextualized environments. Its main

areas of application and study include smart cities, smart health, smart transport, computer security, the fight against cybercrime and privacy protection.

- **Digital Codes**

Coordinating professor: Dr Maria Bras-Amorós
Type: Optional
Credits: 6 ECTS credits
Semester: First

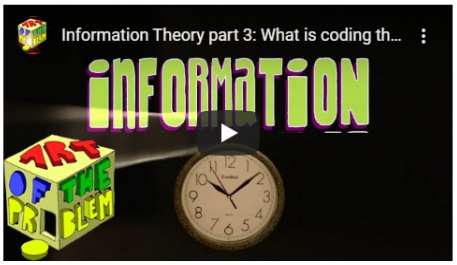
Description: Error control coding is used to detect and correct potential data transmission errors caused by unreliable or noisy channels that may distort the messages we send. The errors produced by the atmosphere as the Meteosat satellite sends photos to earth, for instance, as well as interference-based errors occurring during mobile phone communication and errors in reading CDs or DVDs, may be detected and corrected by this type of coding. For coding to work, the sender encodes the relevant message along with redundant information, which gives the receiver enough data to piece the original message back together. One simple method of this is to send two equal copies of every bit of information. This way, if the original bit or one of its copies are distorted, the receiver can correct it using the two undistorted versions. Adding redundant information is a double-edged sword, however. While it does improve the quality of the received message, it also ups the cost of transmission. To send two copies of every bit, the cost would actually triple. Coding theory studies the design and use of codes with high error-correcting capacity that keep the cost of sending encoded data to a minimum. It also covers the corrective algorithms that allow the original message to be recovered successfully.

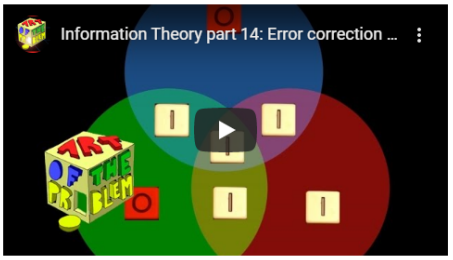
Requirements: Basic knowledge of mathematics (at an official *llicenciatura* or *enginyeria* degree level).

Bibliography: Notes, books and scientific articles.

Course plan

Related videos:





- **Large-Scale Distributed Systems**

Coordinating professor: Dr Joan Manuel Marquès
Type: Optional
Credits: 6 ECTS credits
Semester: Second

Description: This course aims to help students understand the challenges involved in designing, building and analysing distributed computing systems, services and applications. Specifically, the course addresses the issues inherent to the distributed computing and storage of big data, while also honing in on large-scale distributed computing models such as cloud and volunteer computing. Such systems comprise a high number of computers and display less reliability and availability than dedicated solutions. This complicates the layer responsible for managing the infrastructure, which is characteristically heterogeneous and dynamic to a great degree. The course then segues into real-life cases of existing systems and how they address issues of this nature.

Requirements: Ability to read scientific texts in English. Basic knowledge of programming in Java.

Bibliography: Scientific articles on distributed computer systems.

Course plan

- **Cryptography and Blockchain Technology**

Coordinating professor: Dr Oriol Farràs
Type: Optional
Credits: 6 ECTS credits
Semester: Second

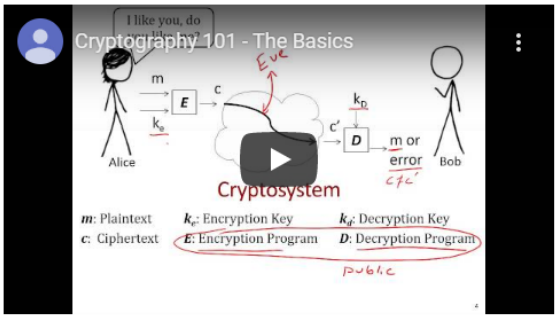
Description: This course aims for students to gain a comprehensive understanding of modern-day cryptography and its use in contemporary environments. The first half of the course is dedicated to introducing students to the most important precedents in cryptography, while also covering the related notions of security, the most relevant attacks to date and the standardized diagrams used today. The remainder of the course addresses the contemporary uses of cryptography and blockchain technology. Students learn about advanced cryptographic protocols for secure computing, the use of cryptography in today's apps, the cryptographic foundations of blockchain technology and cryptocurrencies, and the main results of post-quantum cryptography.
Requirements: Basic knowledge of mathematics (at an official *llicenciatura* or *enginyeria* degree level). Ability to read scientific texts in English.

Provisional bibliography: Notes, books and scientific articles.

Course plan

Related videos:

Nociones generales



TED Talk sobre criptografía

Clase formal sobre criptografía

In collaboration with:

Universitat Rovira i Virgili

- **Data and Algorithm Structures**

Coordinating professor: Dr. Marc Maceira
Type: Optional
Credits: 6 ECTS credits
Semester: First

Description: This course covers data and algorithm structures, introducing students to the key concepts needed to undertake research in the field. Specifically, the course reviews the underlying concepts of algorithmic complexity (i.e. spatial and temporal cost, algorithmic cost calculations and usual orders of magnitude) as well as the basic concepts of data structures (e.g. abstract data types and pointer and memory management). Once students have gained a solid understanding of these key concepts, the course provides an in-depth look at frequently used data structures (i.e. stacks, queues, lists, trees, heaps and hash tables) and offers an introduction to graph algorithms (paths, shortest paths, spanning trees, etc.).

Requirements: Ability to read scientific texts in English. Basic knowledge of programming (preferably in Java).

Bibliography: Sedgewick, R.; Wayne, K. (2011). *Algorithms*. Addison-Wesley Professional.

Relevant software: Java.

Course plan

- **Graph Theory and its Applications**

Coordinating professor: Dr Juan Alberto Rodríguez Velázquez
Type: Optional
Credits: 6 ECTS credits
Semester: First

Description: This course addresses a number of properties of network structure and manipulation, both from a local and global perspective. Specifically, it covers the basics of graph theory, including operations on graphs, distance, connectivity, planarity and colouration, while also going into some fundamental concepts of spectral graph theory. The course also visits a number of current issues, such as graph centrality and centralization measures, topological indices, measures of network bipartivity and reliability measures in weighted networks. The subjects covered in the course allow students to analyse complex networks, including social media, food webs and protein-protein interaction networks. Finally, students are offered a comprehensive introduction to current research in this field.

Requirements: Ability to read scientific texts in English. Basic knowledge of mathematics (at an official *llicenciatura* or *enginyeria* degree level).

Bibliography: Gross, J.L.; Yellen, J. (2006). *Graph Theory and Its Applications*, 2d ed. Chapman & Hall/CRC.

Other resources: Shirinivas, S.G.; Vetrivel, S.; Elango, N.M. (2010). "Applications of Graph Theory in Computer Science: An Overview". *International Journal of Engineering Science and Technology, 2*(9), 4610-4621.

Course plan

- **Artificial Intelligence**

Coordinating professor: Dr Carles Ventura
Type: Optional
Credits: 6 ECTS credits
Semester: Second

Description: This course equips students with a set of advanced artificial intelligence techniques aimed at solving high-frequency computational engineering problems. Accordingly, the course has two main facets. Firstly, students are introduced to the theory that allows engineers to model machine learning, which in turn enables machines to learn and make decisions based on human input. Moreover, the course provides plenty of practical experience. In this regard, students are encouraged to apply the theory to devise solutions to different problems, including those involved in text and visual data classification, content ranking and perception.

Requirements: Ability to read scientific texts in English. Basic knowledge of artificial intelligence and statistics. It is highly recommendable for students to have previously completed a course on machine learning, data mining or similar. Basic knowledge of programming in Python.

Bibliography: UOC modules. Benítez, R.; Escudero, G.; Kanaan, S.; Masip Rodó, D. "Inteligencia Artificial Avanzada". Editorial UOC. ISBN 978-84-9029-887-9.

Relevant software: Python

Other resources: UOC AI videos (in Spanish) and UOC AI videos (in Catalan)

Course plan

- **Operations Research**

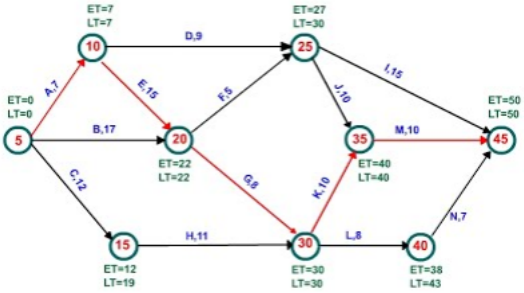
Coordinating professor: Dr Angel A. Juan
Type: Optional
Credits: 6 ECTS credits
Semester: First

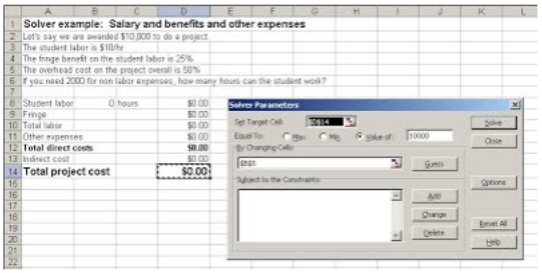
Description: Operations research deals with the rendering of mathematical and computational models and the development of algorithms to solve problems in any area or field (business, industry, society, healthcare, service provision, etc.) through efficient decision-making. This course provides students with the concepts of operations research needed to create models and solve real-life problems by employing techniques such as linear programming, integer programming and heuristic development. The course will also focus on how the concepts and techniques involved in operations research can be applied to overcome problems in the fields of logistics and transport, system and network optimization, and process scheduling.

Requirements: Ability to read scientific texts in English. Basic knowledge of mathematics (at an official *llicenciatura* or *enginyeria* degree level).

Bibliography: Albright, C.; Winston, W. (2012). *Management Science Modeling*. South-Western. ISBN-10: 1111532451 (similar book to the following one from the same authors: *Practical Management Science*).

Relevant software: Microsoft Excel / Open Office Calc Solvers, LINDO / LINGO software





[Course plan]

Link: [INFORMS]

Related videos:

A New View of Analytics and Operations Research

Operational Research: The Science of Better

In collaboration with:

UNIVERSITAT ROVIRA I VIRGILI

- **Modelling through Differential Equations**

Coordinating professors: Dr Dolors Puigjaner / Dr Jordi Villadelprat
Type: Optional
Credits: 6 ECTS credits
Semester: First

Description: In this course, students get a look at how differential equations can be used to create mathematical models of issues arising in any field, such as engineering, physics and biology. Once students have gained sufficient knowledge of the basics, they will work on practical cases from such areas as mechanics, fluid dynamics, heat transfer, epidemic spreading and population growth. The course focuses on three key processes: the mathematical rendering of empirical models, the use of differential equation-based analytical or numerical methods to solve mathematical problems, and results analysis and interpretation.

Requirements: Ability to read scientific texts in English. Basic knowledge of mathematics (at an official *llicenciatura* or *enginyeria* degree level).

Resources:

Reference book: Barnes, B.; Fulford, G.R. (2009). *Mathematical Modelling with Case Studies: A Differential Equations Approach Using Maple™ and MATLAB®*. Editorial CRC Press.

Relevant software: MATLAB and/or GNU Octave

Course plan

- **Metaheuristic Optimization**

Coordinating professor: Dr Angel A. Juan
Type: Optional
Credits: 6 ECTS credits
Semester: First

Description: This course looks at solving problems in discrete domains that have a finite or countably infinite set of solutions. When confronted with problems of this nature, the aim is to find one or more cost solutions that are as close as possible to the optimal solution (if this is not possible to find). Routing, scheduling and placement problems are good examples. Due to the combinatorial explosion of possible solutions, an exhaustive search for the optimal solution becomes infeasible, especially when it comes to medium and large instances of the problem. Accordingly, either incomplete techniques are employed or the model of the problem to be solved is simplified.

The course covers some of the most widely used techniques today, including genetic and evolutionary algorithms, tabu searches, the greedy randomized adaptive search procedure (GRASP) and ant colony optimization (ACO), which may be used individually or in tandem to yield the best results. Finally, the course explores the concept of "simheuristics", a portmanteau of "simulation" and "metaheuristics" referring to the combination of these two approaches to solve combinatorial optimization problems with stochastic components.

Requirements: Ability to read scientific texts in English. Basic knowledge of mathematics and programming (at an official *llicenciatura* or *enginyeria* degree level).

Course plan

Bibliography:

Talbi, E. (2009). *Metaheuristics: From Design to Implementation*. Wiley.
Luke, S. (2013). *Essentials of Metaheuristics*. Lulu.

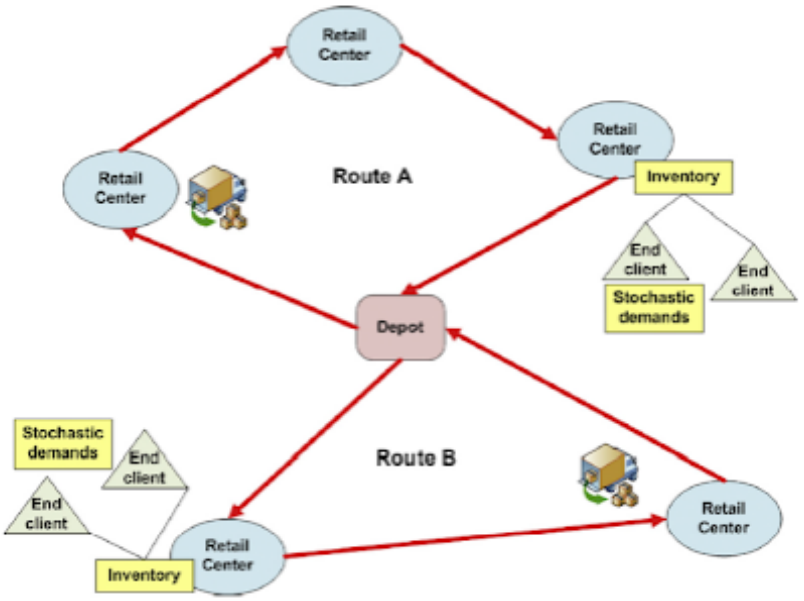
Juan. A.; Faulin, J.; Grasman, S.; Rabe, M.; Figueira, G. (2015). "A review of simheuristics: Extending metaheuristics to deal with stochastic combinatorial optimization problems". *Operations Research Perspectives, 2*, 62-72.

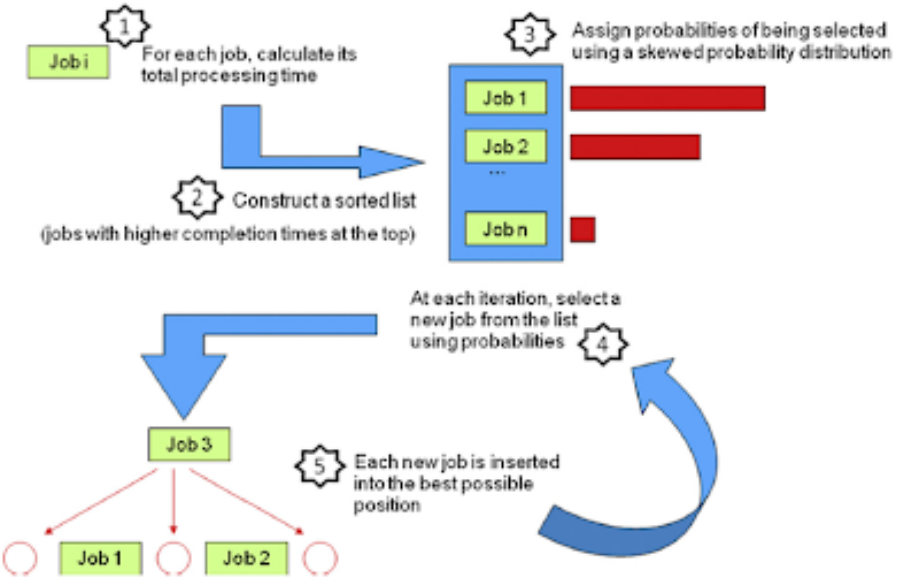
Relevant software: a Java, C or C++ compiler

Link: INFORMS

Other resources: Scientific articles and Java code provided during the course.

Related video:


Retail Center
Retail Center
Retail Center
Route A
Inventory
End client
End client
Stochastic demands
Depot
Stochastic demands
End client
End client
Route B
Inventory
Retail Center
Retail Center


1
Job i
For each job, calculate its total processing time
2
Construct a sorted list
(jobs with higher completion times at the top)
3
Assign probabilities of being selected using a skewed probability distribution
Job 1
Job 2
...
Job n
At each iteration, select a new job from the list using probabilities
4
Job 3
5
Each new job is inserted into the best possible position
Job 1
Job 2

- **Template Matching**

Coordinating professor: Dr Carles Ventura
Type: Optional
Credits: 6 ECTS credits
Semester: Second

Description: This course introduces students to a number of techniques that can be used to extract information from data sets, focusing specifically on template matching techniques in computer vision.

Images are one of the main sources of perceptual information used by the human brain to make decisions. Accordingly, template matching techniques in computer vision are highly valuable, especially given the massive amount of visual data we have today but are unable to analyse using rudimentary methods. Indeed, there are many practical applications for template matching in machine vision; for example, in the fields of security, medicine and automatic inspection, and for autodrive or autopilot systems. During the course, students work to:

- Understand how images are formed.
- Become familiar with the main techniques for processing digital images.
- Comprehend colour perception and colour space representations.

- Become proficient in the main techniques of supervised and unsupervised dimensionality reduction (feature selection and feature extraction), and to learn to apply such techniques to real-life problems.
- Recognize the main machine learning techniques used in automated data classification, and to learn to apply such techniques to real-life problems.

Requirements: Ability to read scientific texts in English. Basic knowledge of mathematics and statistics.

Provisional bibliography: Forsyth, D.A.; Ponce, J. (2012). *Computer Vision: A Modern Approach*. 2/E, Pearson Education.

Relevant software: ImageJ

Course plan

Other resources:

Complementary materials will be used to carry out the practical exercises: Image Processing Learning Resources (HIPR2), the Image Recognition Laboratory, Web-enabled image processing operators (Canny, Gabor), The Color Space Conversions Applet, etc.

- **Complex Networks**

Coordinating professor: Dr Sergio Gómez
Type: Optional
Credits: 6 ECTS credits
Semester: Second

Description: This course covers the basic concepts and algorithms used to analyse complex networks, as well as the models used to display the most relevant features of these networks and the dynamics that take place within them. The course begins by demonstrating the presence of complex networks in a wide range of fields (e.g. biology, technology, ecology, social sciences, economics and linguistics). Likewise, it looks at these networks' most prominent recurring features, such as scale-free degree distributions, transitivity, small-world properties and assortativity. The course pays special attention to complex networks' mesoscopic structures and reviews the main algorithms for mapping such structures in communities. It also looks at the main models of random complex networks, which allow us to understand the appearance of peculiar structural properties. Lastly, the course describes some of the dynamics of complex networks, such as synchronization and epidemic spreading.

Requirements: Ability to read scientific texts in English. Basic knowledge of mathematics and, especially, graphing (at an official *llicenciatura* or *enginyeria* degree level). Ability to programme using any programming language (e.g. MATLAB, Octave, R, C, C++, Java, Python and Visual Basic).

Bibliography: Notes, scientific articles and the book *Networks* by Mark Newman.

Relevant software: The University provides a licence to use MATLAB. Other open access software will be used for network visualization and analysis (e.g. NetworkX, Gephi, igraph, Pajek, Radatools and LightGraphs).

Course plan

- **Finite Elements and Finite Differences: Numerical Methods for PDEs**

Coordinating professor: Dr Carlos García Gómez
Type: Optional
Credits: 6 ECTS credits
Semester: First

Description: The problems that today's engineers are tasked with solving often contain a certain degree of complexity. To overcome this hurdle, numerical techniques or methods have been devised to allow the partial differential equations that govern most relevant processes to be solved numerically. This course serves as a practical introduction to this set of methods, focusing specifically on the more classical methods, or those based on finite differences. This helps us to understand the limitation of such methods and the need to introduce more flexible numerical ones. Modern methods are known under the generic umbrella term of finite element methods and are widely used in all fields of engineering.

Requirements: Ability to read texts in English. Basic knowledge of mathematics and, especially, graphing (at an official *llicenciatura* or *enginyeria* degree level). Understanding of fundamental programming concepts.

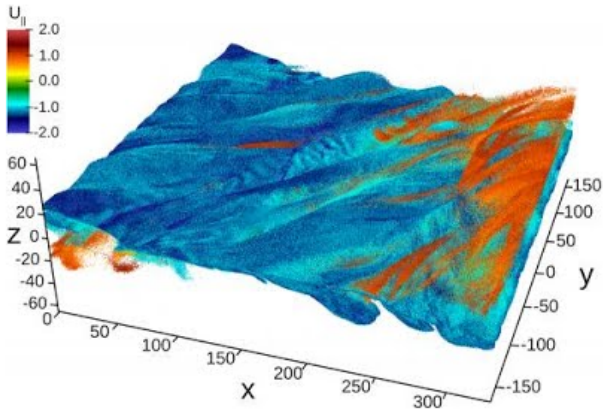
Bibliography:

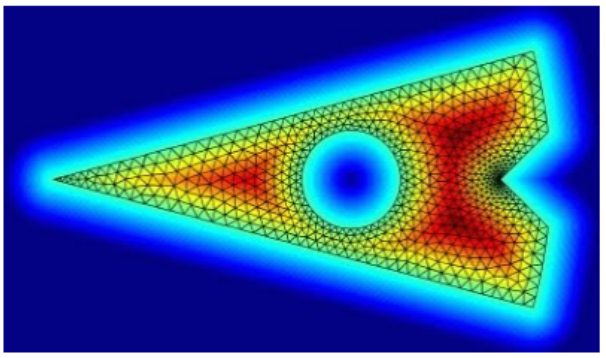
Books
Rao, S.S. (2011). *The Finite Element Method in Engineering*. Elsevier.
Larson, M.G.; Bengzon, F. (2013). *The Finite Element Method: Theory, Implementation and Applications*. Springer.

Relevant software: MATLAB, qtOctave

Course plan

Links: https://en.wikipedia.org/wiki/Finite_element_method





- **Chaotic Dynamical Systems**

Coordinating professor: Dr Antonio Garijo Real
Type: Optional
Credits: 6 ECTS credits
Semester: Second

Description: This course introduces students to the basic concepts of dynamical systems generated by iterated functions. The study of such dynamical systems allows the course to segue into the world of fractal sets, self-similar sets, chaotic sets, Cantor sets, and Julia and Fatou sets. The course also covers two fundamental examples in the study of chaotic dynamical systems; namely, logistic

In collaboration with:

Universitat Rovira i Virgili

application and complex quadratic families. Moreover, the course combines both theoretical and practical exercises.

Requirements: Ability to read scientific texts in English. Basic knowledge of mathematics (at an official *llicenciatura* or *enginyeria* degree level).

Provisional bibliography: Devaney, R. (Ed.) (2003). *An introduction to chaotic dynamical systems*. Westview Press.

Relevant software: The University provides a licence to use MATLAB.

Course plan

- **Final Master's Degree Project**

Coordinating professors: Dr Javier Panadero / Dr Dolors Puigjaner
Type: Compulsory
Credits: 18 ECTS credits
Semester: First and second (year-long course)

Description: The final master's degree project is a professional exercise which students must carry out individually to synthesize the knowledge and skills they have acquired throughout the master's degree. The project is completed under the supervision of a professor, who serves as project supervisor. The final master's degree project can be carried out in any one of a number of subject areas, which students must choose once they have enrolled in the course.

Further information is provided in Section 6 below ("Details regarding the final master's degree project").

4. Teaching and assessment methodology

For each one of your courses, your professor will be there to guide you on your learning path and clear up any queries you many have. The online classrooms have several communication channels, which your professor will use to propose a range of tasks that will help you keep up a solid work pace throughout the course. You and your classmates will also use these channels to share your knowledge with each other.

The UOC also provides the **learning resources** you will need to carry out your course activities. These could be teaching materials, information sources or even support tools, and they will be accessible via the online classroom for each course.

For some of your courses, you will be assessed solely based on the continuous assessment activities you must complete online. For others, there may also be a final test, which you will have to take either online or at one of the UOC's on-site centres.

In **continuous assessment models**, students are required to complete a series of activities, including practical exercises, debates, online presentations, questionnaires, essays and projects.

5. Enrolment recommendations

General recommendation

The time spent by students on each course is determined by the credits allocated to it, with each credit being equivalent to 25 hours' work. With that in mind, you are able to calculate the weekly number of hours you will have to spend on your studies. The total number of credits you enrol on should never exceed the amount of available time you have.

Course recommendations

You can find out about the prior knowledge required for each course in its corresponding course plan, or you can read through the information provided in the "Course information" section above.

Bear in mind that many courses require prior knowledge of mathematics and programming. For full details on each course, return to the "Course information" section.

6. Details regarding the final master's degree project

Coordinating professors: Dr Javier Panadero / Dr Dolors Puigjaner
Type: Compulsory
Semester: First and second (year-long course)
Credits: 18 ECTS credits

The last step on your way to completing your master's degree is the final master's degree project. The course is worth 18 ECTS credits, meaning it requires 450 hours of work.

The final master's degree project is a professional exercise which students must carry out individually to synthesize the knowledge and skills they have acquired throughout the master's degree.

The project is completed under the supervision of a professor, who serves as project supervisor. The final master's degree project can be carried out in any one of a number of subject areas. When you enrol on the course, you must choose one such area and reach out to the professor you would like to supervise you. You will receive ample instructions on how to go about doing this when the time comes.

You will be asked to submit the final draft of your project in the assessment section of the online classroom. This will comprise three parts:

- A written report on the project you have undertaken.
- A product, which may not in fact be necessary depending on the type of project carried out (application, design, study, etc.).
- A video presentation summarizing the project development and results. The project defence is going to be synchronous, in virtual format, by means of a videoconference tool. In the presentation, the student is going to be evaluated by a three member tribunal, the president and two spokespersons. The presentation time slot will be notified further on through the project tutor. Further information in Procedures - Final projects in the campus virtual.

Requirements

- Enrolment: To enrol on the Final Master's Degree Project course, students must have already taken the remaining 42 credits of the master's degree, or be enrolled on them in the same semester.
- Knowledge: The specific prior knowledge required to complete the final project will depend on the chosen subject area.

Selection and assignment of the final master's degree project area

Students must choose from among the UOC- or URV-coordinated final master's degree project research lines laid out below. In order to **select** an area, you must send an email to the corresponding contact person, who will provide you with further information and help you find a professor interested in supervising your project. In order for you to be officially assigned an area and supervisor, you must fill out and submit a **form**.

7. Teaching figures

Master's degree director

This person is responsible for the entire degree, which means coordinating the course professors and ensuring that the master's degree and its content meet quality standards.

As this is a joint degree, there are two directors, one from each of the participating universities:

Dr Dolors Puigjaner
Department of Computer Engineering and Mathematics (URV)
dolors.puigjaner@urv.cat - http://deim.urv.es/~dolors.puigjaner/

Dr Javier Panadero
Faculty of Computer Science, Multimedia and Telecommunications (UOC)
jpanaderom@uoc.edu - https://www.researchgate.net/profile/Javier_Panadero

Tutor

This is a student's go-to person when they have queries or doubts about their studies. The tutor advises, guides and provides overall help to their students throughout the master's degree. Students can get in touch with their assigned tutor at any time through the Virtual Campus's tutoring classroom or by email.

Teaching team

Professors are responsible for organizing their courses, which includes organizing resources and creating useful teaching opportunities. They also help guide their students' on the path to learning and academic achievement. They serve as a guide and an academic example for their students, ensuring bespoke training and fair continuous and final assessment. For more information on all of the master's degree professors, visit https://studies.uoc.edu/en/university-masters-degrees/computational-mathematical-engineering/teaching-team.

8. Research

UOC research groups related with the master's degree:

- **Distributed, Parallel, and Collaborative Systems (DPCS):** DPCS specializes in the development and optimization of distributed and parallel systems and algorithms at different scales (small groups, clusters or internet). It focuses primarily on decentralized systems composed of non-dedicated resources. The group also undertakes research on the design of online collaboration systems and their applications.

- **Internet Computing & Systems Optimization (ICSO):** ICSO-HAROSA is an official programme run by the UOC's Internet Interdisciplinary Institute (http://in3.uoc.edu). The reach of this programme, coordinated by two IN3 research groups, DPCS and GRES-UOC, is decidedly international. ICSO-HAROSA specializes in the development of hybrid algorithms and software to solve optimization problems in the fields of logistics, transport, production and internet systems. It involves researchers from different Spanish universities as well as from other countries, including the UK, USA, France, Portugal, Germany, Austria, Chile, Argentina and Colombia.

- **Scene Understanding and Artificial Intelligence Lab (SUNAI):** SUNAI carries out research related to computer vision, and within this field, it specializes in high-level image interpreting. Its main research lines are facial expression

recognition and analysis, gesture and non-verbal language analysis (2D and 3D), object recognition, and space and scene understanding.

- **Software Engineering Research Group (GRES-UOC):** GRES-UOC carries out research in software modelling and building in complex systems and problems. Specifically, it studies the use of formal methods, knowledge representation and constraint programming and their applications in different contexts, including educational.

URV research groups related with the master's degree

- **Criptografía y Secreto Estadístico (CRISES):** The goal of the CRISES research group – UNESCO Chair in Data Privacy is to create and disseminate technologies for reconciling privacy, security and functionality in the services provided by the information society. The group is led by Prof. Josep Domingo-Ferrer and currently has 26 members, including 13 doctoral degree holders. It has been funded continuously as a consolidated group by the Government of Catalonia since 2002. Among other research projects, the group takes part in the CONSOLIDER "ARES" team (coordinated by Prof. Domingo-Ferrer), in the European 7th Framework Programme's "Inter-Trust" and "Data Without Boundaries" projects, and in a number of projects funded by the Catalan and Spanish governments. The group holds several patents, most of which are being actively exploited, and has created the spin-off known as STAITEC. The group's manager has received a number of distinctions, including the Narcís Monturiol medal for scientific and technological merit, awarded by the Government of Catalonia.

- **Bioinformatics and Environmental Engineering & Chemistry (BIOCENIT):** BIOCENIT is a research group specialized in the study, characterization and modelling of complex systems. The group's activity is structured around three main research lines: (i) computational modelling and environmental engineering; (ii) operations research and biostatistics; and (iii) city science. The group is a former and present participant in several national and international research projects (NSF,

EU FP6 and FP7) and is an active member of several transnational networks and organizations (NanoSafety Cluster, InnaTox, City Protocol Society).

- **Codes, Privacy, and Algebraic Combinatorics (COPRICA1):** This research group specializes in the applications of discrete mathematics in code theory, privacy, cryptography and other areas. It also works on more theoretical topics such as algebraic geometry, finite geometry or algebraic and enumerative combinatorics.

- **Research Group on Artificial Intelligence (Banzai):** Banzai specializes in studying and developing smart systems for medicine. It uses techniques such as data mining, machine learning, engineering and knowledge representation to solve different medical problems. These include modelling care procedures, integrating treatments for patients with several diseases, studying treatment compliance and costs, or analysing the data generated by care information systems. Each year, the group organizes the international workshop Knowledge Representation for Health Care (KR4HC) and, with the publishing company Springer, publishes the homonymous book collection, within the *Lecture Notes in Artificial Intelligence* series.

- **Intelligent Technologies for Advanced Knowledge Acquisition (ITAKA):** ITAKA was founded in January 2007 by Dr Antonio Moreno and Dr Aida Valls, following in the footsteps of the successful Working Group on Multi-Agent Systems (GruSMA), which operated from 2000 to 2006. Its main research lines are distributed systems and data aggregation. The two lines' results are being applied mainly in medicine, tourism and the environment.

- **Discrete and Continuous Dynamical Systems (DCDYNSYS):** This research group works in different branches of what is known generically as dynamical systems, encompassing both the discrete and the continuous variants. In its work, it studies both the theoretical aspects and the applications of dynamical systems in different areas of knowledge (e.g. medicine, biology and chemistry).

- **Discrete Mathematics (MATDISC):** This group specializes in the study of discrete mathematical structures, with particular emphasis on the problems related with

graph theory and hypergraphics.

- **Algorithms Embedded in Physical Systems (Alephsys):** The Alephsys research group specializes in the analysis of complex systems, with particular emphasis on complex networks. Complex networks are ubiquitous: in biology, there are ecological and biochemical networks; in economics, there are transaction networks; in technology, we have internet, telephone communications and transport networks; in sociology, there are the social and collaborative networks, to name just a few examples. Today, computers and technology in general are continuously generating all sorts of data (known as big data). However, it is not easy to extract information from this data. Complex network analysis techniques do just this, however, analysing their structure, identifying key components and understanding the relationships between structure and dynamics. Among the most interesting dynamics are the spread of epidemics, the creation of fail-safe networks and the appearance of emerging phenomena, which are all studied within Alephsys.

- **RIVI (Robotics and Intelligent Vision):** this research group is composed of both professors of the Department of Computer Engineering and Mathematics and the Department of Electrical, Electronic and Automatic Engineering. The RIVI group is dedicated to the development of innovative solutions in various areas of robotics and artificial vision through the application of advanced computing techniques. Its research lines include image analysis and processing, pattern recognition, 3D modelling, mobile robotics, multi robot exploration, etc.

- **CloudLab**: This group combines a multidisciplinary team focused on the study of distributed systems and telematic services. The group's research focuses on the creation of new distributed services and middleware infrastructures for the storage, sharing and distribution of information in different work environments (collaborative, educational, medical, etc.). In particular, the group has important contributions to large-scale distributed systems (Cloud, P2P) and adaptive and regional middleware. One of its main lines of research focuses on the development of adaptive systems and network storage.

- **Smart Technologies Research**: The Smart Technologies research group focuses on the application of ICT to the creation of contextual environments and their applications. The main areas of application and study are: smart cities, smart health, smart transportation, computer security, the fight against cybercrime and privacy protection.

PhD grants

Both the URV and the UOC offer PhD grants for students who have finished their master's degrees and want to complete a doctoral programme. Some related links are included below:

- **URV PhD grants**
- **UOC doctoral degree grants**

Other grant and funding opportunities in Europe can be found at:

- **Euraxess portal**

9. Relevant links

Information about the master's degree on the URV website:
https://www.urv.cat/en/studies/master/courses/computational-engineering/

Information about the master's degree on the UOC website:
http://cv.uoc.edu/estudiant/mes-uoc/en/universitat/plans/MS87/index.html#seccio-5

10. Student help services

Please send us any queries or issues you may have in relation to the master's degree through the Help Service option located on the top menu on the UOC's Virtual Campus. Bear in mind, however, that the URV is the coordinating university, which means it takes care of most of the procedural aspects of the degree:

- enrolment modifications, validations, certificate requests, requests to move up or push back the final project presentation, etc.: https://www.urv.cat/en/studies/master/administrative-procedures/
- Secretary's Office (enrolled students): matricula.scs@urv.cat