Universitat Autònoma de Barcelona

Research and Innovation 2016/2017

Code: 43475
ECTS Credits: 6

Degree	Type	Year	Semester
4313136 Modelling for Science and Engineering	OB	0	1

Contact

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Use of languages

Principal working language: english (eng)

Teachers

Juan Camacho Castro

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Prerequisites

There are no specific prerequisites. Students must have mathematical skills at a graduate level of a scientific degree.

Objectives and Contextualisation

The aim of this module is to show students the variety of fields in which they will be able to apply the tools acquired during the Master courses. Hopefully they will be able to use them as guidance when looking for Internships in Companies and Institutions and also when choosing a topic and an advisor for the Master's Thesis. We also expect that it will help them to find a career path.

Skills

- Analyse complex systems in different fields and determine the basic structures and parameters of their workings.
- Analyse, synthesise, organise and plan projects in the field of study.
- Apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of specialisation.
- Apply techniques for solving mathematical models and their real implementation problems.
- Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
- Formulate, analyse and validate mathematical models of practical problems in different fields.
- Integrate knowledge and use it to make judgements in complex situations, with incomplete information, while keeping in mind social and ethical responsibilities.
- Isolate the main difficulty in a complex problem from other, less important issues.
- Look for new areas to open up within the field.
- Recognise the human, economic, legal and ethical dimension in professional practice.
- Solve complex problems by applying the knowledge acquired to areas that are different to the original ones.
- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.

Learning outcomes

1. Analyse, synthesise, organise and plan projects in the field of study.
2. Apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of specialisation.
3. Check the validity of the model with regard to the behaviour of the real system.
4. Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
5. Describe the functional dependencies of the system with regard to the different parameters
6. Design mathematical models that represent the system and its behaviour.
7. Identify the parameters that determine how a system works.
8. Implement the proposed solutions reliably and efficiently.
9. Integrate knowledge and use it to make judgements in complex situations, with incomplete information, while keeping in mind social and ethical responsibilities.
10. Isolate the main difficulty in a complex problem from other, less important issues.
11. Look for new areas to open up within the field.
12. Recognise the human, economic, legal and ethical dimension in professional practice.
13. Solve complex problems by applying the knowledge acquired to areas that are different to the original ones.
14. Solve mathematical models efficiently.
15. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.

Content

We have two types of activities during the semester: to attend a four innovative mini-courses and attend a series of lectures given by people who work for companies or researchers working in universities or research centres**.**

The courses are the following**:**

1. **Open Data.** Basic tools for handing open data.-Open data capture and preprocessing.- Analysis of open data.-Visualization.
2. **Genetic algorithms.** An Overview of Combinatorial Optimization.- Theoretical Foundations of Genetic Algorithms.- Genetic Algorithms in Engineering and Optimization.- Genetic Algorithms in Natural Evolution.
3. **Numerical weather forecast models.** Numerical Weather Prediction (NWP): A general overview, Basic concepts of Atmospheric Modelization: Approximations and Parameterizations, NWP models and computational power, Applications of Numerical Weather Prediction at the Meteorological Service of Catalonia (SMC)
4. **Self-organization & Complex networks.** Emergent behaviors.-Self-organization in space and time.-Complex networks: Random, Small World and Scale-Free networks.-Processes on networks.

We will invite specialists in the fields of Modelling Complex Systems, Modelling of Engineering and Mathematical Modelling. Among the others we will have talks from people coming from:

- SMC, Servei Meteorològic de Catalunya, http://www.meteo.cat
- CRM, Centre de Recerca Matemàtica, http://www.crm.cat
- ICC, Institut Català de Ciències del Clima, http://www.ic3.cat/
- IDIBAPS: Institució d'investigacions biomèdiques August Pi i Sunyer, http://www.idibaps.org/
- CBC, Center for Brain and Cognition (UPF), http://cbc.upf.edu/
- BSC-CNS, Barcelona Supercomputing Center, http://www.bsc.es

Methodology

The attendance at the four courses is compulsory. The methodology of that courses is based on master classes which consist in the presentation of the theory, examples and some case studies.

Relating the lectures, they will be announced previously on the virtual campus of the module Research and Innovation. There the students will find the title of the talk, the name of the speaker, a short summary and links of interest. Students have to attend at least 50% of the scheduled lectures.

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Attendance at courses and lectures	40	1.6	2, 4, 6, 11, 12
Making a report of some database (teamwork)	36	1.44	1, 2, 5, 6, 7, 8, 9, 10, 13, 14, 15
Project of two other courses	74	2.96	1, 2, 5, 6, 7, 8, 9, 10, 13, 14, 15

Evaluation

The students have to present at the evaluation of the Open data course (mandatory and team working) and also at two more courses chosen from Genetic Algorithms, Numerical weather forecast models and Self-organization & Complex Networks.

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Attendance at courses and lectures	10%	0	0	2, 3, 4, 11, 12
Making a report of some database (teamwork)	30%	0	0	1, 2, 5, 6, 7, 8, 9, 10, 13, 14, 15
Project of two other courses	60%	0	0	1, 2, 5, 6, 7, 8, 9, 10, 13, 14, 15

Bibliography

Bibliography and links of interest:

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- UCI Machine Learning Repository: http://archive.ics.uci.edu/ml/
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- Melanie Mitchell, An Introduction to Genetic Algorithms, A Bradford Book, The MIT Press, Cambridge Massachusetts, 1999.
- David Beasley, David R. Bully and Ralph R. Martinz, An Overview of Genetic Algorithms (Part 1: Fundamentals and Part 2: Research Topics
- Arkady Pikovsky, Michael Rosenblum, and Jürgen Kurths. Synchronization. A universal concept in nonlinear sciences. Cambridge Press, 2003

- S.H. Strogatz. SYNC. Rythms of nature, rythms of ourselves, Penguin, 2003.
- Mark J. Newmann. Networks: An Introduction. Oxford University Press, 2010
- A-L. Barabasi. Linked: How Everything Is Connected to Everything Else and What It Means for Business, Science, and Everyday Life. Basic Books, 2014
- N. Boccara. Modeling Complex Systems. Springer, 2010
- T. Starkweather, S. McDaniel, K. Mathias, D. Whitley, C. Whitley, A Comparison of Genetic Sequencing Operators