Universitat Autònoma de Barcelona

2020/2021

Research and Innovation

Code: 43475
ECTS Credits: 6

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

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

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Use of Languages

Principal working language: english (eng)

Teachers

Antonio Lozano Bagen

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Prerequisites

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

Competences

- 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 three 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. Introduction to Deep Learning. Introduction, linear regression, logistic regression, model evaluation methods. Dense neuronal networks. Convolutional neuronal networks. Recurrent neuronal networks

2. Introduction to Python for analytical purposes. Python basics. Data with Python. Problem solving with Python. Machine Learning with Python.

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

We will invite specialists in the fields of Modelling Complex Systems, Modelling of Engineering, Mathematical Modelling and Data Science. 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
- BSC-CNS, Barcelona Supercomputing Center, http://www.bsc.es
- CVC, Computer Vision Center (UAB),https://www.cvc.uab.es
- IBM, International Business Machines, https://www.ibm.com/es-es
- IIIA-CSIC, Institut d'Investigació en Intel·ligència Artificial, https://www.iiia.csic.es

Methodology

The methodology of the three 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.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Attending Lectures	16	0.64	1, 2, 3, 5, 6, 10, 7, 8, 11, 9, 4, 15, 12, 14, 13
Attending Mini-courses	22	0.88	1, 2, 3, 5, 6, 10, 7, 8, 11, 9, 4, 15, 12, 14, 13

Assessment

Students must submit three projects corresponding to the three announced courses.

The Deep Learning course will take place on September 15, 22 and 29 and October 6. The corresponding report must be submitted by October 31 to the virtual campus. It must be done in teams of 2 or 3 people.

The proposed Python for analytical course will be held on October 13, 20 and 27 and November 3. The deadline to submit the report is November 30. It must be done in teams of 2 or 3 people.

Finally, the courses on numerical weather forecast models will be presented on 13, 17 and 24 November. The report must be submitted by December 18. It must be done in teams of 3 people.

On the other hand, attendance at the talks contributes to 10% of the final grade.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Attending Lectures	10%	16	0.64	3, 5, 7, 9, 4, 15
Making a report on Deep Learning	30%	32	1.28	1, 2, 3, 5, 6, 10, 7, 8, 11, 9, 4, 15, 12, 14, 13
Making a report on Numerical Weather Forecast Models	30%	32	1.28	3, 5, 7, 9, 4, 15
Report on Python for analitical purposes	30%	32	1.28	1, 2, 3, 5, 6, 10, 7, 8, 11, 9, 4, 15, 12, 14, 13

Bibliography

- Bibliography and links of interest

- http://shop.oreilly.com/product/0636920052289.do
- http://www.deeplearningbook.org/
- *T. Starkweather, S McDaniel, K. Mathias, D. Whitley, C. Whitley. A Comparison of Genetic Sequencing Operatots.*
- Ahrens, C. Meteorology Today: An Introduction to Weather, Climate, and the Environment. International student edition. Brooks/Cole, CengageLearning. 2009
- Holton, J. R., & Hakim, G. J. (2012). *An introduction to dynamic meteorology* (Vol. 88). Academic press.
- Wilks, D. S. (2011). *Statistical methods in the atmospheric sciences* (Vol. 100). Academic press.
  Gutiérrez, J. M. (2004). Redes probabilísticas y neuronales en las ciencias atmosféricas. Ministerio de Medio Ambiente, Secretaría General Técnica.