Course guide
240AR022 - 240AR022 - Pattern Recognition & Machine Learning

Last modified: 16/05/2023

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 707 - ESAII - Department of Automatic Control.

Degree: MASTER'S DEGREE IN AUTOMATIC CONTROL AND ROBOTICS (Syllabus 2012). (Compulsory subject).
MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: ANDREU CATALA MALLOFRE

Others: CECILIO ANGULO
RAUL BENITEZ

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
4. The student will be able to model, formulate and solve problems of control, taking into account its uncertainty, by Fuzzy logic based controllers.
5. The student will be able to select and program pattern recognition methods and learning based on the type of problem, after distinguishing if the situation so requires

Generical:
1. Ability to conduct research, development and innovation in the field of systems engineering, control and robotics, and as to direct the development of engineering solutions in new or unfamiliar environments, linking creativity, innovation and transfer of technology
2. Ability to reason and act based on the so-called culture of safety and sustainability
3. Have adequate mathematical skills, analytical, scientific, instrumental, technological, and management information.

Transversal:
6. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

7. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

CT6. (ENG) Capacitat d'adaptació als canvis, sent capaçd'aplicar tecnologirs noves i avançades i altres progressos rellevants, amb iniciativa i esperit innovador.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

TEACHING METHODOLOGY

The methodology of the course combines master classes, laboratory sessions and autonomous learning through the development of problem assignments, scientific papers analysis and projects development.

LEARNING OBJECTIVES OF THE SUBJECT

Learning Outcomes:
At the end of the course the student should be able:
- To identify, select and implement machine learning, selection of features, and pattern recognition methods according to the problem's characteristics
- To suitably represent the structured spatiotemporal information
- To use numerical methods for optimization, machine learning algorithms and pattern recognition systems by considering conventional software packages.

Mandatory Contents:
- Linear models for clustering, classification, and regression.
- Artificial neural networks, support vector machines and kernel methods.
- Learning by demonstration and graphical models.
- Continuous latent variables and sequential data.

STUDY LOAD

Type	Hours	Percentage
Hours small group	27,0	18.00
Hours large group	27,0	18.00
Self study	96,0	64.00

Total learning time: 150 h

CONTENTS

Exploratory data analysis

Description:
• Visualization of multidimensional data
• Data clustering algorithms
• Dimensionality reduction and Principal Component Analysis
• Data imputation algorithms
• Feature extraction
• Independent Component Analysis

Related activities:
Master class, problem solving and independent learning through exercises

Full-or-part-time: 20h
Theory classes: 4h
Laboratory classes: 4h
Self study : 12h

Probabilistic Models

Description:
• Discriminant analysis
• Probabilistic models for classification
• Mixture Models and the Expectation-Maximization algorithm
• Parameter estimation in probabilistic models
• Classification and Regression Trees

Full-or-part-time: 22h
Theory classes: 6h
Practical classes: 4h
Self study : 12h

Neural Networks and Deep Learning

Description:
• NN structure and learning
• Feed forward NN and Back Propagation
• Radial Basis Functions
• Regularization of NN
• Deep Learning methods

Full-or-part-time: 26h
Theory classes: 6h
Practical classes: 4h
Self study : 16h

Support Vector Machines and Kernel methods

Description:
This topic deals with:
· Statistical Learning Theory
· Kernel trick

Related activities:
Master class, troubleshooting and independent learning through exercises

Full-or-part-time: 22h
Theory classes: 4h
Practical classes: 2h
Self study : 16h

Learning by demonstration

Description:
This topic deals with:
· Reinforcement Learning
· Applications in robotics

Related activities:
Master class, troubleshooting and independent learning through exercises

Full-or-part-time: 16h
Theory classes: 4h
Practical classes: 2h
Self study : 10h

GRADING SYSTEM

The evaluation system will consist on the following elements:
- E1. Paper-based exams (40%)
- E2. Questions, test, exercises, short reports (25%)
- E3. Project report (35%)
- E4. Re-evaluation, equivalent to E1 (40%)

During the spring semester of the 2019-2020 academic year, and as a result of the health crisis due to Covid19, the qualification method will be the following. The evaluation of the subject will be divided into three parts:
First part (35%)
Themes: 1. Exploratory Data Analysis. 2. Probabilistic Models. 3. Artificial Neural Networks (excluding Deep Learning).
Two different evaluation possibilities:
a) Online Partial Exam (29th April)
b) Complete the Machine Learning Coursera (the global grade of the course will be kept)
Second part (30%)
Themes: 3. Deep Learning (only). 4. Support Vector Machines. 5. Learning by demonstration.
Evaluation: three deliverables, one for each item with the same weight
Third part (35%)
Group project report

The deadlines and specificities of each evaluation act are available on Atenea

BIBLIOGRAPHY

Basic:
- Duda, Richard O; Hart, Peter E; Stork, David G. Pattern classification [on line]. 2nd ed. New York [etc.]: John Wiley & Sons, cop. 2001 [Consultation: 08/02/2022]. Available on: https://ebookcentral-proquest-com/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=699526. ISBN 0471056693.
- Bishop, Christopher M. Pattern recognition and machine learning. New York: Springer, cop. 2006. ISBN 9780387310732.

RESOURCES

Computer material:
- scikit-learn: Machine Learning in Python. https://scikit-learn.org/stable/