Degree competences to which the subject contributes

Basic:
- CB7. Ability to integrate knowledges and handle the complexity of making judgments based on information which, being incomplete or limited, includes considerations on social and ethical responsibilities linked to the application of their knowledge and judgments.

Specific:
- CEA12. Capability to understand the advanced techniques of Knowledge Engineering, Machine Learning and Decision Support Systems, and to know how to design, implement and apply these techniques in the development of intelligent applications, services or systems.
- CEA13. Capability to understand advanced techniques of Modeling, Reasoning and Problem Solving, and to know how to design, implement and apply these techniques in the development of intelligent applications, services or systems.
- CEP1. Capability to solve the analysis of information needs from different organizations, identifying the uncertainty and variability sources.

General:
- CG1. Capability to plan, design and implement products, processes, services and facilities in all areas of Artificial Intelligence.
- CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.

Transversal:
- CT2. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.
- CT4. 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.

Teaching methodology

Presentation classes and group project classes

Learning objectives of the subject

1. To known and use advanced unsupervised machine learning and reinforcement learning techniques for application on all the domains of engineering and science
### Study load

| **Total learning time:** 40h 30m | Hours large group: | 40h 30m | 100.00% |
### Content

#### Data Mining, a global perspective

**Degree competences to which the content contributes:**

**Description:**
Brief introduction to what is Data Mining and Knowledge Discovery, the areas they are related to and the different techniques involved.

#### Pre-processing and unsupervised data transformation

**Degree competences to which the content contributes:**

**Description:**
This topic will include different algorithms for unsupervised data preprocessing such as data normalization, discretization, outliers detection, dimensionality reduction and feature extraction (PCA, ICA, SVD, linear and non-linear multidimensional scaling and non-negative matrix factorization).

#### Unsupervised Machine Learning

**Degree competences to which the content contributes:**

**Description:**
This topic will include classical and current algorithms for unsupervised learning from machine learning and statistics including hierarchical and partition algorithms (K-means, Fuzzy C-means, Gaussian EM, graph partitioning, density based algorithms, grid based algorithms, unsupervised ANN, affinity propagation, ...).

#### Unsupervised methodologies in Knowledge Discovery and Data Mining

**Degree competences to which the content contributes:**

**Description:**
This topic will include current trends on knowledge discovery for data mining and big data, (scalability, any time clustering, one pass algorithms, approximation algorithms, distributed clustering, ..).

#### Advanced topics in unsupervised learning

**Degree competences to which the content contributes:**

**Description:**
This topic will include an introduction to different advanced topics in unsupervised learning such as consensus clustering, subspace clustering, biclustering and semisupervised clustering.

#### Unsupervised learning for sequential and structured data

**Degree competences to which the content contributes:**
Description:
This topic will include algorithms for unsupervised learning with sequential data and structured data, such as sequences, strings, time series and data streams, graphs and social networks.

Basic concepts of Reinforcement Learning

Degree competences to which the content contributes:
Description:
This topic describes the framework of reinforcement learning as the agent-learning of a behavior by interacting with the environment. This framework will be mathematically formalized. Finally, the concepts of reward, long-term reward, Value functions and Policy function will be introduced. Concepts will be illustrated with several examples.

Basic reinforcement learning algorithms: Model based methods

Degree competences to which the content contributes:
Description:
This topic introduce the model-based-algorithms of RL. We will see Dynamic Programming methods of Policy Iteration (PI) and Value Iteration (VI). Asynchronous versions of the algorithm will also be described. Finally, we will stress the importance of convergence of the algorithms and the optimality of the policy learnt by the algorithms.

Basic reinforcement learning algorithms: Model free methods

Degree competences to which the content contributes:
Description:
We will see algorithm able to learn without a model of the world. We will present Monte Carlo, Q-learning and Sarsa algorithms. We will extend these methods to TD(lambda) and n-estimators backups. The role of exploration in learning will be discussed.

Function approximation

Degree competences to which the content contributes:
Description:
This topic explains what to do when the state space is too large to be represented with a table. We will discuss the advantages and problems of the two main approaches for this problem: Parametric and No parametric methods. We will show how to apply know supervised methods as RBFs, Trees, SVMs and Deep Learning methods to RL.

Policy gradient methods
### Degree competences to which the content contributes:

#### Description:
In some cases, value function approaches are not appropriate, for instance, when the action space is continuous or when long-term reward is not the best guide for learning. This topic shows approaches developed to solve these cases. We will describe the actor-critic approach and also the Vanilla policy gradient method and REINFORCE and TROP algorithms.

### State of the art applications of RL.

#### Degree competences to which the content contributes:

#### Description:
In this topic, we will describe the latest practical application of RL: Atari, Go, robotic applications and NLP.

### Planning of activities

#### Unsupervised learning

- **Hours**: 54h 30m
  - Theory classes: 18h
  - Practical classes: 0h
  - Laboratory classes: 0h
  - Guided activities: 2h 18m
  - Self study: 34h 12m

- **Description**: This activity develops the topics of the unsupervised learning part of the course

- **Specific objectives**: 1

#### Reinforcement learning

- **Hours**: 54h 30m
  - Theory classes: 18h
  - Practical classes: 0h
  - Laboratory classes: 0h
  - Guided activities: 2h 18m
  - Self study: 34h 12m

- **Description**: This activity develops the syllabus of the reinforcement learning part of the course

- **Specific objectives**: 1
Qualification system

The evaluation will be based on small questionnaires about each topic of the course (20%) and a coursework to choose between to write a report on the state of the art for a particular topic of the course or to implement machine learning algorithms (80%).

Bibliography

Others resources:

Hyperlink

http://www.cs.upc.edu/~bejar/URL/URL.html

http://www.cs.upc.edu/~mmartin/url-RL.html