### 230625 - MLEARN - Machine Learning From Data

**Coordinating unit:** 230 - ETSETB - Barcelona School of Telecommunications Engineering  
**Teaching unit:** 739 - TSC - Department of Signal Theory and Communications  
**Academic year:** 2018  
**Degree:**  
- MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit Optional)  
- MASTER'S DEGREE IN INFORMATION AND COMMUNICATION TECHNOLOGIES (Syllabus 2009). (Teaching unit Optional)  
**ECTS credits:** 5  
**Teaching languages:** English

### Teaching staff

**Coordinator:** ENRIC MONTE MORENO  
**Others:** ENRIC MONTE MORENO

### Prior skills

- Calculus, algebra and signal processing

### Requirements

- none

### Degree competences to which the subject contributes

**Specific:**  
1. Ability to apply information theory methods, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing to communication and audiovisual systems.

**Transversal:**  
2. 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.  
3. 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.  
4. 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.

### Teaching methodology

- Blackboard classes and deliverables

### Learning objectives of the subject

**Learning objectives of the subject:**  
The objectives are to introduce students to the main algorithms for learning from data / machine learning, and for understanding how to make the algorithms work with real data.

**Learning results of the subject:**  
- Ability to understand the general principles of the machine learning algorithms.
- Ability to distinguish the relevant properties of algorithms for a given problem.
- Knowledge of the main machine learning techniques

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group:</th>
<th>39h</th>
<th>31.20%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>86h</td>
<td>68.80%</td>
</tr>
</tbody>
</table>
## Content

| **Geometry of Machine Learning** | **Learning time:** 15h  
|                                | Theory classes: 5h  
|                                | Self study : 10h |
| **Description:** | Description of the geometric model for pattern classification based on partition of space by planes and its relation to the neural models. |
| **Related activities:** | Individual Deliverable |

| **Bayesian Framework** | **Learning time:** 12h  
|                       | Theory classes: 4h  
|                       | Self study : 8h |
| **Description:** | A classification model based on Bayes' formula is presented, its plausibility. From the general formula the typology of classification models obtained is explained. In parallel geometric interpretations are presented. |
| **Related activities:** | Individual Deliverable |

| **Linear Discriminant Functions and lineal regression** | **Learning time:** 7h  
|                                                         | Theory classes: 2h  
|                                                         | Self study : 5h |
| **Description:** | Based on the simplest model geometry, it is a hyperplane, the duality between classification and function approximation is presented. Geometric model is related to the Bayesian framework and underlying assumptions are clarified. The various ways of calculating the model parameters are also presented. |
| **Related activities:** | Individual Deliverable |
### Multilayer perceptron and radial basis functions

**Learning time:** 23h  
Theory classes: 6h  
Self study: 17h

**Description:**  
The underlying geometry of the models of multilayer perceptron and radial basis functions is described. From the geometrical properties of the models and the types of problems that can be solved with these models are derived. Then are presented the algorithms to estimate the parameters. Also the conditions under which they can function properly. A Bayesian interpretation of the geometry associated with the two models is given.

**Related activities:**  
Individual Deliverable

### Support Vector machines (SVM)

**Learning time:** 18h  
Theory classes: 6h  
Self study: 12h

**Description:**  
The geometric justification of the SVM, and from the geometry of the cost function that allows to derive the parameters is presented. Limitations and generalization to nonlinear regression are also presented. Finally problems that are likely to be solved by this technique are discussed.

**Related activities:**  
Individual Deliverable

### Exploratory Data analysis

**Learning time:** 14h  
Theory classes: 4h  
Self study: 10h

**Description:**  
Different techniques are presented to study how the data are distributed in order to choose the technique of ‘machine learning’ more suitable for the data type.

**Related activities:**  
Individual Deliverable
### Decision trees

**Description:**
The intuition behind the decision trees, and its interpretations as logical functions and as a partition of space by means of planes parallel to the axes is presented. The CART algorithm is presented, justifying each step. Subsequently, other algorithms are presented to train decision trees and extensions of the basic structure.

**Related activities:**
Individual Deliverable

<table>
<thead>
<tr>
<th>Learning time: 15h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 5h</td>
</tr>
<tr>
<td>Self study : 10h</td>
</tr>
</tbody>
</table>

### Feature selection and high dimensionality data

**Description:**
Feature selection methods based on projections and combinatorial optimization are presented. The problems that occur when metrics are designed to work in areas of very large dimension are discussed. These problems appear in applications such as genetic or text processing.

**Related activities:**
Individual Deliverable

<table>
<thead>
<tr>
<th>Learning time: 9h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 3h</td>
</tr>
<tr>
<td>Self study : 6h</td>
</tr>
</tbody>
</table>

### Random Forests and boosting

**Description:**
In this topic we present ways of combining algorithms to improve the results. The justifications of the methods that combine decision trees and underlying statistical concepts are based are also presented.

**Related activities:**
Individual Deliverable

<table>
<thead>
<tr>
<th>Learning time: 6h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td>Self study : 4h</td>
</tr>
</tbody>
</table>
Planning of activities

EXTENDED ANSWER TEST (FINAL EXAMINATION)

<table>
<thead>
<tr>
<th>Weekly deliverables</th>
<th>Hours: 2h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Weekly essay and practices in R language.</td>
</tr>
</tbody>
</table>

Qualification system

Max of \{(40\% \text{ deliverables}, 60\% \text{ final exam}), (100\% \text{ final exam})\}

Bibliography

Basic:


Complementary: