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: 2019
Degree: MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Teaching unit Compulsory)
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: Primavera: ENRIC MONTE MORENO
Tardor: JOSEP VIDAL
Others: ENRIC MONTE MORENO
JOSEP VIDAL
VERONICA VILAPLANA

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

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
<th>39h</th>
<th>31.20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total learning time: 125h</td>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Hours small group:</td>
<td>0h</td>
<td>0.00%</td>
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<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

<table>
<thead>
<tr>
<th>Introduction to the techniques of machine learning</th>
<th>Learning time: 33h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 8h</td>
</tr>
<tr>
<td></td>
<td>Self study: 25h</td>
</tr>
</tbody>
</table>

**Description:**
Description of the types of machine learning models based on data, emphasizing structure, geometry and the relationship with deep learning.

**Related activities:**
Individual Deliverable+ individual practices

<table>
<thead>
<tr>
<th>Bayesian Framework</th>
<th>Learning time: 18h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 6h</td>
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<tr>
<td></td>
<td>Self study: 12h</td>
</tr>
</tbody>
</table>

**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. The Bayesian framework is generalized to the approximation of functions and parametric regression.

**Related activities:**
Individual Deliverable+Individual practices

<table>
<thead>
<tr>
<th>Linear Discriminant Functions and lineal regression</th>
<th>Learning time: 7h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 2h</td>
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<tr>
<td></td>
<td>Self study: 5h</td>
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</tbody>
</table>

**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+Individual practices
**Multilayer perceptron and radial basis functions**

**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. The techniques that make deep learning work are described.

**Related activities:**
- Individual Deliverable
- Individual practices

**Learning time:** 21h
- Theory classes: 7h
- Self study: 14h

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**Exploratory Data analysis**

**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

**Learning time:** 3h
- Theory classes: 1h
- Self study: 2h

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**Advanced methods for machine learning**

**Description:**
Advanced SVM methodologies, unsupervised techniques, k-nearest neighbours, decision trees, random forests and boosting are described.

**Related activities:**
- Weekly essay and ML practical application

**Learning time:** 39h
- Theory classes: 13h
- Self study: 26h
### Planning of activities

#### EXTENDED ANSWER TEST (FINAL EXAMINATION)

<table>
<thead>
<tr>
<th>Weekly deliverables</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: weekly essay + lab practice at home</td>
<td>Theory classes: 2h</td>
</tr>
</tbody>
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#### Qualification system

Autumn term: Lab work: 25%. Delivery of homework: 20%. Participation in the proposed ML challenge: 15%. Final exam: 40%.

Spring term: Max of (40% deliverables, 60% final exam), (100% final exam)

#### Bibliography

**Basic:**


**Complementary:**