270217 - AA1 - Machine Learning 1

Degree competences to which the subject contributes

Specific:
CE1. Skillfully use mathematical concepts and methods that underlie the problems of science and data engineering.
CE3. Analyze complex phenomena through probability and statistics, and propose models of these types in specific situations. Formulate and solve mathematical optimization problems.
CE8. Ability to choose and employ techniques of statistical modeling and data analysis, evaluating the quality of the models, validating and interpreting them.
CE9. Ability to choose and employ a variety of automatic learning techniques and build systems that use them for decision making, even autonomously.

Generic:
CG1. To design computer systems that integrate data of provenances and very diverse forms, create with them mathematical models, reason on these models and act accordingly, learning from experience.
CG2. Choose and apply the most appropriate methods and techniques to a problem defined by data that represents a challenge for its volume, speed, variety or heterogeneity, including computer, mathematical, statistical and signal processing methods.

Transversal:
CT3. Efficient oral and written communication. Communicate in an oral and written way with other people about the results of learning, thinking and decision making; Participate in debates on topics of the specialty itself.
CT7. Third language. Know a third language, preferably English, with an adequate oral and written level and in line with the needs of graduates.

Teaching methodology

El temario se expone en las clases de teoría de forma muy motivada (por qué se explica) y motivadora (por qué es importante conocerlo) complementado con muchos ejemplos.

Las clases de teoría introducen todo los conocimientos, las técnicas, conceptos y resultados necesarios para alcanzar un nivel bien fundamentado y entendido. Estos conceptos se ponen en práctica en las clases de laboratorio. En estas se proporciona código R que permite resolver ciertos aspectos de un problema de análisis de datos con la o las técnicas correspondientes al tema en curso. Este laboratorio también sirve de guía para la parte correspondiente de la práctica, que desarrollan los alumnos a lo largo del curso.

Hay un trabajo práctico evaluable, que trabaja un problema real a elegir por el propio estudiante y que recoge e integra los conocimientos y las competencias de todo el curso. También se evalúa mediante el trabajo práctico la competencia genérica de comunicación eficaz escrita.

Learning objectives of the subject

1. Formulate the problem of automatic learning from data, and get to know the types of tasks that can be given.
2. Organize the resolution flow of a machine learning problem, analyzing the possible options and choosing the most suitable for the problem.
3. Decide, defend and criticize a solution to a machine learning problem, arguing the strong and weak points of the approach.
4. Know and know how to apply linear techniques to solve supervised learning problems.
5. Know and know how to apply mono and multilayer neural network techniques to solve supervised learning problems.
6. Know and know how to apply support vector machines to the resolution of supervised learning problems.
7. Know and know how to apply the basic techniques for the resolution of unsupervised learning problems, with emphasis on data clustering tools.
8. Know and know how to apply the basic techniques for solving reinforcement learning problems.
9. Know and know how to apply ensemble techniques to solve supervised learning problems.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
<th>30h</th>
<th>20.00%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Hours small group:</td>
<td>30h</td>
<td>20.00%</td>
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<tr>
<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>90h</td>
<td>60.00%</td>
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</table>
## 270217 - AA1 - Machine Learning 1

### Content

**Introduction to Machine Learning**

<table>
<thead>
<tr>
<th>Degree competences to which the content contributes:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> General information and basic concepts. Description and approach of problems attacked by automatic learning. Supervised learning (regression and classification), non-supervised (clustering) and semi-supervised (reinforcement and transductive). Modern examples of application.</td>
</tr>
</tbody>
</table>

**Unsupervised machine learning: clustering**

<table>
<thead>
<tr>
<th>Degree competences to which the content contributes:</th>
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<tbody>
<tr>
<td><strong>Description:</strong> Definition and approach of unsupervised machine learning. Introduction to clustering. Probabilistic algorithms: k-means and Expectation-Maximization (E-M).</td>
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</table>

**Supervised machine learning (I): linear regression methods**

<table>
<thead>
<tr>
<th>Degree competences to which the content contributes:</th>
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<tbody>
<tr>
<td><strong>Description:</strong> Maximum likelihood for regression. Errors for regression. Least squares: analytical (pseudo-inverse and SVD) and iterative (gradient descent) methods. Notion of regularization. L1 and L2 regularized regression: algorithms ridge regression, LASSO and Elastic Net.</td>
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</table>

**Supervised machine learning (II): linear methods for classification**

<table>
<thead>
<tr>
<th>Degree competences to which the content contributes:</th>
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<tbody>
<tr>
<td><strong>Description:</strong> Maximum likelihood for classification. Error functions for classification. Bayesian Generative Classifiers: LDA/QDA/RDA, Naïve Bayes and k-nearest neighbours.</td>
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</tbody>
</table>

**Hierarchical methods: decision trees**

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<thead>
<tr>
<th>Degree competences to which the content contributes:</th>
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<tbody>
<tr>
<td><strong>Description:</strong> General construction of decision trees. Split criteria: gain in entropy and Gini. Regularization in decision trees. CART trees for regression and classification.</td>
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</tbody>
</table>

**Feed-forward shallow neural networks**

| Degree competences to which the content contributes: |
# Machine Learning 1

<table>
<thead>
<tr>
<th><strong>Description:</strong></th>
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<tbody>
<tr>
<td>Feed-forward shallow neural networks (one hidden layer). Activation functions. Multilayer perceptron with one hidden layer and RBF (radial basis function network) and their training algorithms.</td>
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### Recurrent shallow neural networks

<table>
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<th><strong>Degree competences to which the content contributes:</strong></th>
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<tr>
<td><strong>Description:</strong></td>
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### Kernel based learning methods

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<tbody>
<tr>
<td><strong>Description:</strong></td>
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### Ensemble methods

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<th><strong>Degree competences to which the content contributes:</strong></th>
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<tr>
<td><strong>Description:</strong></td>
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### Reinforcement learning

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<tr>
<td><strong>Description:</strong></td>
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</table>
### Planning of activities

| Development of topic 1 | Hours: 5h 18m  
Theory classes: 2h  
Practical classes: 0h  
Laboratory classes: 0h  
Guided activities: 0h  
Self study: 3h 18m |
<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>1</td>
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</table>

| Development of topic 2 | Hours: 12h 36m  
Theory classes: 4h  
Practical classes: 0h  
Laboratory classes: 2h  
Guided activities: 0h  
Self study: 6h 36m |
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<tbody>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>1, 3, 7</td>
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</tbody>
</table>

| Development of topic 3 | Hours: 18h  
Theory classes: 6h  
Practical classes: 0h  
Laboratory classes: 2h  
Guided activities: 0h  
Self study: 10h |
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<tbody>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>1, 4</td>
</tr>
</tbody>
</table>

| Development of topic 4 | Hours: 15h 18m  
Theory classes: 5h  
Practical classes: 0h  
Laboratory classes: 2h  
Guided activities: 0h  
Self study: 8h 18m |
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<tbody>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>1, 2, 4</td>
</tr>
</tbody>
</table>
## Development of topic 6

### Hours:
- Theory classes: 7h
- Practical classes: 0h
- Laboratory classes: 2h
- Guided activities: 0h
- Self study: 11h 36m

### Specific objectives:
- 1, 2, 5

## Development of topic 7

### Hours:
- Theory classes: 3h
- Practical classes: 0h
- Laboratory classes: 1h
- Guided activities: 0h
- Self study: 5h

### Specific objectives:
- 1, 2, 5

## Development of topic 8

### Hours:
- Theory classes: 7h
- Practical classes: 0h
- Laboratory classes: 2h
- Guided activities: 0h
- Self study: 11h 36m

### Specific objectives:
- 1, 6

## Development of topics 5 and 9

### Hours:
- Theory classes: 8h
- Practical classes: 0h
- Laboratory classes: 2h
- Guided activities: 0h
- Self study: 13h 18m

### Specific objectives:
- 1, 9
## Development of topic 10

**Hours:** 9h  
Theory classes: 3h  
Practical classes: 0h  
Laboratory classes: 1h  
Guided activities: 0h  
Self study: 5h  

### Specific objectives:
1, 8

## Control session for the practical work

**Hours:** 2h  
Guided activities: 2h  
Self study: 0h  

### Specific objectives:
1, 2, 3, 4, 5, 6, 7, 8, 9

## Delivery of the practical work

**Hours:** 3h  
Guided activities: 3h  
Self study: 0h  

### Specific objectives:
1, 2, 3, 4, 5, 6, 7, 8, 9

## Qualification system

The subject is evaluated through a partial exam, a final exam and a practical work in which a real problem is attacked, writing the corresponding report.

The final grade is calculated as:

Grade = 0.4 * Work + 0.6 * max (Final, 1/3 * Partial + 2/3 * Final)

For those students who can and want to attend re-evaluation, the re-evaluation exam grade will replace max (Final, 1/3 * Partial + 2/3 * Final).
Bibliography

Basic:


