Course guide
270677 - SANS - Statistical Analysis of Networks and Systems

Unit in charge: Barcelona School of Informatics
Teaching unit: 701 - DAC - Department of Computer Architecture.

Degree: MASTER'S DEGREE IN INNOVATION AND RESEARCH IN INFORMATICS (Syllabus 2012). (Optional subject).

Academic year: 2022  ECTS Credits: 6.0  Languages: English

LECTURER

Coordinating lecturer: JORGE GARCÍA VIDAL

Others: Primer quadrimestre:
JOSE MARIA BARCELÓ ORDINAS - 10
JORGE GARCÍA VIDAL - 10

PRIOR SKILLS

Basic knowledge of probability theory, linear algebra and calculus

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEE2.2. Capability to understand models, problems and algorithms related to computer networks and to design and evaluate algorithms, protocols and systems that process the complexity of computer communications networks.

General:
CG4. Capacity for general and technical management of research, development and innovation projects, in companies and technology centers in the field of Informatics Engineering.

Transversal:
CTR5. APPROPRIATE ATTITUDE TOWARDS WORK: Capability to be motivated by professional achievement and to face new challenges, to have a broad vision of the possibilities of a career in the field of informatics engineering. Capability to be motivated by quality and continuous improvement, and to act strictly on professional development. Capability to adapt to technological or organizational changes. Capacity for working in absence of information and/or with time and/or resources constraints.

Basic:
CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

TEACHING METHODOLOGY

Some materials will be posted online. The main results will be explained in the blackboard. Classes with problem solving and application examples.

LEARNING OBJECTIVES OF THE SUBJECT

1. The main goal of the course is to develop in the students quantitative modeling skills, based on probabilistic techniques.
STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self study</td>
<td>96,0</td>
<td>64.00</td>
</tr>
<tr>
<td>Hours large group</td>
<td>54,0</td>
<td>36.00</td>
</tr>
</tbody>
</table>

Total learning time: 150 h

CONTENTS

**Probability models**

Description:
Probability axioms, basic combinatorics, random variables, independence and conditional probability, expected values (review, only problems and online material), inequalities (Markov, Chebyshev, Jensen), (weak) Law large numbers, entropy and mutual information. Properties of Gaussian distributions, central limit theorem.

**Linear models**

Description:

**Estimation. Basic Machine Learning techniques for classification and regression**

Description:

**Graphical models and dynamic systems**

Description:
ACTIVITIES

**Probability models**

**Description:**
Probability axioms, basic combinatorics, random variables, independence and conditional probability, expected values (review, only problems and online material), inclusion/exclusion, conditional independence, inequalities (Markov, Chebyshev, Jensen), examples: Bernouilli, Binomial, Multinomial, Poisson, (weak) Law large numbers, entropy and mutual information. Density functions, examples: uniform, exponential, Gaussian (review, problems and online material), beta, dirichlet, (eigenvalues/eigenvectors, symmetric, positive definite matrices video), multivariate gaussian, memoryless of exponential distribution. Properties of Gaussian distributions, central limit theorem.

**Specific objectives:**
1

**Related competencies:**
CG4. Capacity for general and technical management of research, development and innovation projects, in companies and technology centers in the field of Informatics Engineering.
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CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

**Full-or-part-time:** 12h
Theory classes: 6h
Practical classes: 6h

**Linear models**

**Description:**
Spectral theorem for symmetric matrices. Positive-definite matrices, quadratic forms. SVD. Dimensionality reduction. PCA.

**Specific objectives:**
1

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CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

**Full-or-part-time:** 12h
Theory classes: 6h
Practical classes: 6h
**Estimation. Basic Machine Learning techniques for regression and classification**

**Description:**

**Full-or-part-time:** 12h

Theory classes: 6h
Practical classes: 6h

**Graphical models & dynamic systems**

**Description:**

**Specific objectives:**
1

**Related competencies:**
CG4. Capacity for general and technical management of research, development and innovation projects, in companies and technology centers in the field of Informatics Engineering.
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**Full-or-part-time:** 12h

Theory classes: 6h
Practical classes: 6h

**Self-evaluating tests**

**Specific objectives:**
1

**Related competencies:**
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**Full-or-part-time:** 18h 30m

Guided activities: 1h 30m
Self study: 17h
self-assessment test T2

Specific objectives:

1

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CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

Full-or-part-time: 18h 30m
Guided activities: 1h 30m
Self study: 17h

self assessment test T3

Specific objectives:

1

Related competencies:

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CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

Full-or-part-time: 20h 30m
Guided activities: 1h 30m
Self study: 19h
self assessment test T4

Specific objectives:
1

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Full-or-part-time: 20h 30m
Guided activities: 1h 30m
Self study: 19h

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Homework 1

Full-or-part-time: 4h 30m
Self study: 4h 30m

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Homework 2

Full-or-part-time: 6h
Self study: 6h

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Homework 3

Full-or-part-time: 6h
Self study: 6h

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Homework 4

Full-or-part-time: 6h
Self study: 6h
**GRADING SYSTEM**

The evaluation is based on the development of several projects. Each of the projects will be evaluated (0=<mark=<10) and weighted according to the complexity of the project. The final mark for the course (FM) will be:

\[ FM = \text{Sum}_i (W_i \times M_i) \]

Where:

- \( W_i \) is the weight of each project \( i = 1, ..., N \)
- \( M_i \) is the mark of each project \( i = 1, ..., N \)

The number of projects may vary over time, but in general, the following projects are foreseen:

* P1 (25%): Basic probability, information theory, and linear algebra,
* P2 (25%): Estimation, ML and Bayesian approaches
* P3 (25%): Understanding Bias-Variance tradeoff
* P4 (25%): Basic regression and classification

**BIBLIOGRAPHY**

**Basic:**

**Complementary:**

**RESOURCES**

**Hyperlink:**
- http://www.inference.phy.cam.ac.uk/mackay/itila/