Course guides
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: 2020 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.

Generical:
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>Hours large group</td>
<td>24.0</td>
<td>16.0</td>
</tr>
<tr>
<td>Hours small group</td>
<td>12.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Guided activities</td>
<td>6.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Hours medium group</td>
<td>12.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Self study</td>
<td>96.0</td>
<td>64.0</td>
</tr>
</tbody>
</table>

Total learning time: **150 h**

CONTENTS

**Discrete 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.

**Continuous probability models**

**Description:**
Sigma-algebras, measures, examples of non-measurable sets, probability axioms (revisited), Real numbers: Borel sigma-algebra, Sequences: Cylinder sigma-algebra (optional, online material), Cumulative Distribution Functions, 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.

**Bayesian estimation, classification and regression**

**Description:**
Bernouilli variable: Maximum likelihood and bayesian estimation. Conjugate distributions. Bayesian classification and regression. Intro to MChs and MCMC (optional, online material)

**Graphical models and dynamic systems**

**Description:**
ACTIVITIES

Discrete probability models

Description:
Review of basic discrete probability models. Inclusion/exclusion, conditional independence, inequalities (Markov, Chebyshev, Jensen), examples: Bernouilli, Binomial, Multinomial, Poisson, (weak) Law large numbers, entropy and mutual information

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.
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.
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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

Continuous probability models

Description:
Sigma-algebras, measures, examples of non-measurable sets, probability axioms, Real numbers: Borel sigma-algebra, Sequences: Cylinder sigma-algebra (optional, online material), Cumulative Distribution Functions, Density functions, examples: uniform, exponential, Gaussian (review, online material), beta, dirichlet, (eigenvalues/eigenvectors, symmetric, positive definite matrices, review online material), multivariate gaussian, memoryless of exponential distribution. Properties of Gaussian distributions, central limit theorem.

Specific objectives:
1

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Full-or-part-time: 12h
Theory classes: 6h
Practical classes: 6h
### Bayesian estimation, classification and regression

**Description:**
Bernouilli variable: Maximum likelihood and bayesian estimation. Conjugate distributions. Bayesian classification and regression. Intro to Markov Chains and MCMC (optional, online material)

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

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.

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.

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.

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

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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 two different activities

- 4 tests, one per each part of the course (Ai, i=1..4)
- 5 Homeworks (Ti, i=1..4, T5 is optional)

\[
A = \frac{1}{4} \sum_{i=1}^{4} A_i \\
T = \frac{1}{4} \sum_{i=1}^{4} T_i + \frac{1}{5} x T_5
\]

Final mark of the course (F):

\[
F = 0.5 x A + 0.5 T
\]

**BIBLIOGRAPHY**

**Basic:**

**Complementary:**

**RESOURCES**

**Hyperlink:**
- http://cataleg.upc.edu/record=b1269009~S1*cat