Course guide
270209 - TEOI - Information Theory

Last modified: 11/07/2024

Unit in charge: Barcelona School of Informatics
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.
748 - FIS - Department of Physics.

Degree: BACHELOR'S DEGREE IN DATA SCIENCE AND ENGINEERING (Syllabus 2017). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: ADRIÁN FRANCISCO TAUSTE CAMPO

Others: Primer quadrimestre:
ADRIÁN FRANCISCO TAUSTE CAMPO - 11, 12, 13
JOSE VIDAL MANZANO - 11, 13

PRIOR SKILLS

Fundamentals of probability, statistics and stochastic processes

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.
CE7. Demonstrate knowledge and ability to apply the necessary tools for the storage, processing and access to data.
CE8. Ability to choose and employ techniques of statistical modeling and data analysis, evaluating the quality of the models, validating and interpreting them.

Generical:
CG5. To be able to draw on fundamental knowledge and sound work methodologies acquired during the studies to adapt to the new technological scenarios of the future.

Transversal:
CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.
CT6. Autonomous Learning. Detect deficiencies in one's own knowledge and overcome them through critical reflection and the choice of the best action to extend this knowledge.
CT7. Third language. Know a third language, preferably English, with an adequate oral and written level and in line with the needs of graduates.

Basic:
CB1. That students have demonstrated to possess and understand knowledge in an area of ??study that starts from the base of general secondary education, and is usually found at a level that, although supported by advanced textbooks, also includes some aspects that imply Knowledge from the vanguard of their field of study.
CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.
CB4. That the students can transmit information, ideas, problems and solutions to a specialized and non-specialized public.
CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy

TEACHING METHODOLOGY

50% of lectures in which the participation of students is stimulated, followed by 50% of practical classes based on exercises and programming of algorithms with the aim of bringing information theory to practical applications related to data science engineering.

LEARNING OBJECTIVES OF THE SUBJECT

1.To acquire the knowledge necessary to understand the basic principles of treatment, compression, cryptography and analysis of data based on Shannon's theory.

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours large group	30,0	20.00
Hours small group	30,0	20.00

Total learning time: 150 h

CONTENTS

Discrete random variables and processes

Description:
Probability, ensembles of random variables, stochastic processes, Márkov processes

Measures of information

Description:
Information theory, entropy, joint entropy and mutual information, data processing inequality, Fano's inequality, applications

Information of data sources

Description:
Codes, asymptotic equipartition property, data compression, the high probability set, non-independent sources

Source coding

Description:
Properties of codes, unique decodability, mínimum average length, Huffman codes, dictionary codes

Capacity of discrete channels

Description:
Joint typical sequences, channel capacity theorem, separability of source and channel coding.

Channel codes

Description:
Introduction to error correction codes, block codes

Cryptography

Description:
Shannon theory of secrecy systems; main theorem; one-time pad; symmetric cryptography in practice

ACTIVITIES

Development of lecture "Discrete random variables and processes"

Specific objectives:
1

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CT7. Third language. Know a third language, preferably English, with an adequate oral and written level and in line with the needs of graduates.
CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.

Full-or-part-time: 8h
Self study: 4h
Theory classes: 2h
Practical classes: 2h

Development of lecture "Measures of information"

Specific objectives:
1

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Full-or-part-time: 18h
Self study: 8h
Theory classes: 5h
Practical classes: 5h

Development of lecture "Information of data sources"

Specific objectives:
1

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CB4. That the students can transmit information, ideas, problems and solutions to a specialized and non-specialized public.
CE7. Demonstrate knowledge and ability to apply the necessary tools for the storage, processing and access to data.
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CE1. Skillfully use mathematical concepts and methods that underlie the problems of science and data engineering.
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Full-or-part-time: 14h
Self study: 4h
Theory classes: 5h
Practical classes: 5h

Development of lecture "Source coding"

Specific objectives:
1

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Full-or-part-time: 20h
Self study: 8h
Theory classes: 6h
Practical classes: 6h

Development of lecture "Capacity of discrete channels"

Specific objectives:
1

Related competencies :
CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy
CB4. That the students can transmit information, ideas, problems and solutions to a specialized and non-specialized public.
CB1. That students have demonstrated to possess and understand knowledge in an area of ??study that starts from the base of general secondary education, and is usually found at a level that, although supported by advanced textbooks, also includes some aspects that imply Knowledge from the vanguard of their field of study.
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Full-or-part-time: 11h
Self study: 4h
Theory classes: 3h
Practical classes: 4h

Development of lecture "Channel codes"

Specific objectives:
1

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CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy
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CE8. Ability to choose and employ techniques of statistical modeling and data analysis, evaluating the quality of the models, validating and interpreting them.
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Full-or-part-time: 19h
Self study: 4h
Theory classes: 6h
Practical classes: 9h

Development of lecture "Cryptography"

Specific objectives:
1

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Full-or-part-time: 7h
Self study: 4h
Theory classes: 3h

GRADING SYSTEM

There will be a mid-term test of two hours duration at the 8th week and a final exam. The grade is calculated as the maximum of (final exam grade, 0.6 * final exam grade + 0.4 * mid-term exam grade).
The re-evaluation exam, for fails who have attended lectures and final exam, will consist of one exam to be held in July and that will be considered at 100% for the final grading.

BIBLIOGRAPHY

Basic:
- Cover, T.M.; Thomas, J.A. Elements of information theory. 2nd ed. New York [etc.]: John Wiley & Sons, 2006. ISBN 0471241954.
- Höst, S. Information and communication theory. Wiley IEEE Press, 2019. ISBN 9781119433781.
- Mackay, D.J.C. Information theory, inference, and learning algorithms. Cambridge University Press, 2003. ISBN 9780521642989.