UAB
Universitat Autònoma de Barcelona

Theory of Information and Coding

Code: 104354
ECTS Credits: 6

Degree	Type	Year	Semester
2503758 Data Engineering	OB	2	2

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

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Use of Languages

Principal working language: catalan (cat)

Some groups entirely in English: No

Some groups entirely in Catalan: Yes

Some groups entirely in Spanish: No

Teachers

Joaquim Borges Ayats

Joan Bartrina Rapesta

Prerequisites

There are no prerequisites. However, students should be familiar with the most basic concepts of fundamental linear algebra, mathematical analisys and probability theory.

Objectives and Contextualisation

To study the mathematical theory of information, for the discrete case, based on C.E. Shannon's papers in 1948. To study sources of data, source coding, data compression and channel coding. To study error-detecting and correcting codes for an efficient data transmission or data storage.

Competences

- Generate innovative and competitive proposals in professional activity and research.
- Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
- Transmit data with efficiency, precision and security.
- Work cooperatively in complex and uncertain environments and with limited resources in a multidisciplinary context, assuming and respecting the role of the different members of the group.

Learning Outcomes

1. Analyse and evaluate the advantages and disadvantages of a lossy, a lossless and a quasi-lossless compression.
2. Decide on the most suitable type of coding for the characteristics of the signal and the transmission channel.
3. Formulate methods for information compression and encoding for error correction.
4. Generate innovative and competitive proposals in professional activity and research.
5. Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
6. Work cooperatively in complex and uncertain environments and with limited resources in a multidisciplinary context, assuming and respecting the role of the different members of the group.

Content

1.- Basic concepts. Discrete memoryless sources.

1.1.- The problems of communication.

1.2.- Measure of information.

1.3.- Shannon's model of discrete memoryless source.

1.4.- Entropy function.

1.5.- Mutual information.

1.6.- Discrete memoryless channels. Capacity.

2.- Source coding.

2.1.- Introduction and objectives.

2.2.- Constant length codes.

2.3.- Variable length codes. Unique decipherability.

2.4.- Shannon's bounds.

2.5.- Construction of optimal codes.

3.- Data compression.

3.1.- Types of compression. Measures of compression.

3.2.- Compression techniques.

3.3.- Statistical methods.

3.4.- Dictionary techniques.

3.5.- Compression of sound and images.

4.- Discrete memoryless channels.

4.1.- Models for channels.

4.2.- Calculation of channel capacity.

4.3.- Decoding rules.

4.4.- The fundamental theorem,

5.- Coding theory I: linear codes.

5.1.- Block codes. Minimum distance decoding.

5.2.- Introduction to finite fields.

5.3.- Linear codes. Generator matrices.

5.4.- Equivalent codes. Systematic encoding.

5.5.- Dual codes. Parity-check matrices.

5.6.- Decoding. Standard array and syndrome.

5.7.- Some families of important linear codes.

5.8.- Application to distributed storage.

6.- Coding theory II: cyclic codes.

6.1.- Cyclic codes as ideals of polynomial rings.

6.2.- Generator and parity-check polynomials.

6.3.- Systematic encoding with cyclic codes.

Methodology

Theoretical content will be taught through lectures, although students will be encouraged to actively participate in the resolution of examples. During problem sessions, a list of exercises will be resolved. Students are encouraged to solve the problems on their own in advance. Students will also be encouraged to present their own solutions in class. During practice sessions, topics related to the lectures will be developed. Specially, data compression and coding theory. Campus Virtual will be used for communication between lecturers and students (material, updates, announcements, etc.).

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Practice sessions	12	0.48	1, 2, 3, 4, 5, 6
Problem sessions	12	0.48	1, 2, 5
Theory lectures	26	1.04	1, 2, 5
Type: Supervised			
Tutoring and consultations	17	0.68	1, 2, 3, 5
Type: Autonomous			
Independent study	25	1	1, 2, 3, 4, 5
Preparing exercices and practice	25	1	1, 2, 3, 4, 5
Preparing the final test	25	1	1, 2, 3, 5

Assessment

Continuous-assessment dates will be published on Campus Virtual. Specific programming may change when necessary. Any such modification will always be communicated to students through Campus Virtual, which is the usual communication platform between lecturers and students.

Subject assessment (out of 10 points) will be carried out as follows:

- Two individual partial tests, 6 points (3 points each). As part of continuous assessment, the first test will take place during lectures; the second will take place on the date specified by coordination. These individual tests will consist mostly of exercises in the style of those worked on during the course; a smaller part will consist of more theoretical questions.

- Exercise resolutions, 1.5 points. As part of continuous assessment, activities must be carried out or exercises must be solved by applying the given methods.

- Mandatory practices, 2.5 points. As part of continuous assessment, certain computer-based implementations must be fulfilled. A re-assessment date for this part (if required) will be published.

- Final exam, 6 points. Those who have not passed the subject through the individual partial tests will have the option to take final exam as a re-assessment grade to compensate the individual partial tests. There is therefore no separatere-assessment for partial tests; this exam covers material from the entire course. It will consist mainly of exercises in the style of those worked on during the course; a smaller part will consist of more theoretical questions.

Notwithstanding other disciplinary measures deemed appropriate, and in accordance with the academic regulations in force, assessment activities will receive a zero whenever a student commits academic irregularities that may alter such assessment. Assessment activities graded in this way and by this procedure will not be re-assessable. Irregularities contemplated in thisprocedure include, among others: the total or partial copying of an evaluation activity; allowing others to copy; presenting group work that has not been done entirely by the members of the group; presenting any materials prepared by a third party as one's own work, even if these materials are translations or adaptations, including work that is not original or exclusively that of the student; having communication devices (such as mobile phones, smart watches, etc.) accessible during theoretical-practical assessment tests (individual exams).

An overall grade of 5 or higher is required to pass the subject. A "non-assessable" grade cannot be assigned to students who have participated in any of the individual partial tests or the final exam. No special treatment will be given to students who have completed the course in the previous academic year, except that the practice grade previously obtained can be assigned to this course gradebook. In order to pass the course with honours, the final grade must be a 9.0 or higher. Because the number of students with this distinction cannot exceed 5% of the number of students enrolled in the course, this distinction will be awarded to whoever has the highest final grade.

In the case of exercise resolution, a review may be requested after the date of the activity. For all other assessment activities, a place, date and time of review will be indicated allowing students to review the activity with the lecturer. If students do not take part in this review, no further opportunity will be made available.

To consult the academic regulations approved by the Governing Council of the UAB, please follow this link: http://webs2002.uab.es/afers_academics/info_ac/0041.htm

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes

Final test	60%	3	0.12	1, 2, 5
Practice	25%	2	0.08	1, 2, 3, 4, 5, 6
Tests based on exercise resolutions in exercise-base classes	15%	3	0.12	1, 2, 3, 5

Bibliography

*L. Huguet i J. Rifà. Comunicación Digital. Ed. Masson, 1991.

*D. Salomon: Data compression - The Complete Reference, 4th Edition. Springer 2007.

*R.B. Ash. Information Theory. John Wiley and Sons Inc, 1965.

*G. Alvarez. Teoría matemática de la información. Ediciones ICE, 1981.

*T.C. Bell, J.G. Cleary i I.H. Witten. Text Compression. Prentice Hall, 1990.

*F.J. MacWilliams and N.J.A. Sloane. The theory of error-correcting codes. North-Holland, Amsterdam, 1977.