Last update: 13/05/2009

11864 - CODIS - CODING THEORY

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics

Teaching unit: 726 - MA II - Department of Applied Mathematics II

Academic year: 2009

Degree: DEGREE IN MATHEMATICS (Syllabus 1992). (Teaching unit Optative)
DOCTORATE IN APPLIED MATHEMATICS, PLA 2005 (Syllabus 2007). (Teaching unit Optative)
MASTER IN APPLIED MATHEMATICS (Syllabus 2006). (Teaching unit Optative)
MASTER IN MATHEMATICAL ENGINEERING (Syllabus 2006). (Teaching unit Optative)

Credits: 7,5 Teaching languages: Catalonian

Lecturers

Coordinator: XAMBO DESCAMPS, SEBASTIAN

Teaching methodology

Theory lectures, problem-solving sessions and an assigned practical.
Theoretical sessions:
Systematic explanation of the different topics on the syllabus with illustrations using selected examples.

Problem-solving sessions:
Problems concerning theory are regularly posed for students to solve (either individually or in small groups), who must in turn explain them in the problemsolving classes.

Practicals:
Work carried out with interactive webs, particularly /www.wiris.com/cc/, to be done in indepedent study time.

Learning objectives of the subject

To familiarize students with the theory and practice of the schemes currently used for coding and decoding oriented towards correcting errors made in the transmission of information through a digital channel.
* To learn the Basic features of Shannon¿s theory of information (source coding, channel coding, decoding schemes) and understand why it is to be regarded as the origin of the digital era.
* Fundamental properties, most relevant examples and most important applications of Block Codes. This includes a direct and detailed treatment of alternating codes, and, in particular, Reed-Solomon Codes, BCH Codes and classical Goppa Codes.
* Introduction to Goppa geometric codes.
* Fundamental properties, most relevant examples and most important applications of
Convolutional Codes and Trellis Coding. Viterbi decoding and its applications.
* Codes composed in series and in parallel. Turbo decoders. Iterative decoders.
* Computational treatment of self -correcting codes.

Skills to be acquired:
* To learn the foundations of Shannon¿s information theory and the limits to the possibilities regarding error correction.
* To learn how to analyze which error-correction scheme is most appropriate for a given
demand.
* To understand the relations exisiting among different areas of mathematics, especially algebra, coding theory and the theory of self -correcting codes.
* To learn which codes are currently used in the different digital systems and to understand how they work.
* Introduction to some of the unsolved problems involved in the theory and practice of coding, with a focus on error correction.

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Content

Information theory

Description:
Communication systems and information theory. The problem of detecting and correcting errors. Coders. Decoding criteria. The Shannon limit. Preliminaries of the most commonly used Coding/Decoding schemes.

Block codes

Description:
Block codes. Perfect codes. Examples of Codes. Operations with Codes. Parameter fitting. Fundamental problem of coding by blocks.

Linear codes

Description:
Coding and decoding of linear codes. Weight distribution, MacWilliams¿ identities. Hamming and Golay codes. Reed Muller codes. Cyclic Codess. BCH (Bose Chaudhuri Hocquenghem) Codes. Reed Solomon and Justesen Codes. Classical Goppa Codes. Quadratic residue Codes. Alternating Codes.

Decoding

Description:
Berlekamp-Massey-Sugiyama and Peterson-Gorentein-Zierler decoders for alternating codes. The Meggitt decoder for cyclic codes. Trellis coding and the Viterbi decoder.

Convolutional codes and Turbo codes

Description:
Convolutional coders (structure and properties). Concatenation Codes (in series and in parallel). Interleavers. Turbo decoding.

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Applications

Description:
Introduction to the Codes used in several technological applications (modems, data recording systems, mobile telephone, digital television, submarine communication, interplanetary communication, etc.).

Qualification system

A theory exam carrying a maximum of 3 points (two theory topics, one halfway through the course and another at the end, on a list of 15 topics taken from the didactical units studied on the course). A problem-solving exam carrying a maximum of 4 points. A practical assignment carrying a maximum of 2 points (1 for the written part to be handed in on the day of the final exam, and 1 for the oral summary given at the end of the coruse). Up to 1 extra point may be awarded for work done in the problem-solving sessions (solutions and explanation will be taken into account).

Prior skills

* Linear Algebra
* Basic probability and statistics.

Bibliography

Basic:

Justesen, J.; Hoeholdt, T.. A course in error-correcting codes. European Math. Soc., 2004.

Xambó, S.. Block error-correcting codes: a computational primer. Springer-Verlag, 2003.

Heegard, C.; Wicker, S.B.. Turbo coding. Kluwer Academic Publishers, 1999.

Schlegel, C.. Trellis Coding. IEEE Press, 1997.

Lin, S.; Costello, D.J.. Error control coding: fundamentals and applications. Prentice-Hall, 2004.

Complementary:

Proakis, J.G.; Salehi, M.. Communication systems engineering. Prentice-Hall, 2002.

Brunat, J. M.; Ventura, E.. Informació i codis. Edicions UPC, 2001.

Lint Van, J.H.. Introduction to coding theory. Springer Verlag, 1999.

Pretzel, O.. Error-correcting codes and finite fields student edition. Clarendon Press, 1996.

MacWilliams, F.; Sloane, N.. The theory of error correcting codes. North-Holland, 1977.