Course guide
230611 - IT - Information Theory

Last modified: 25/05/2023

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.

Degree: MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).

Academic year: 2023 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

PRIOR SKILLS

Solid knowledge of random variables and probability.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Ability to apply information theory methods, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing to communication and audiovisual systems.
2. Ability to design and dimension transport, broadcast and distribution networks for multimedia signals

Transversal:
3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

TEACHING METHODOLOGY

- Lectures.
- Problems solved individually or in groups by the student.
- Presentation of a journal paper previously agreed with the professor by the student individually.

LEARNING OBJECTIVES OF THE SUBJECT

Understanding the general principles and the most common tools in the field of information theory and its application to formulate the fundamental limits of source and channel coding, both point-to-point and distributed or multiuser.

STUDY LOAD

Type	Hours	Percentage
Hours large group	39,0	31.20
Self study	86,0	68.80

Total learning time: 125 h

CONTENTS

Introduction

Description:
Introduction to the field of Information Theory. Course contents, organization and grading.

Full-or-part-time: 3h 07m
Theory classes: 1h
Self study : 2h 07m

Information Measures and typicality.

Description:
Entropy, joint entropy, conditional entropy, relative entropy, mutual information, typical sequences, jointly typical sequences, properties, inequalities, stochastic Processes, Markov Chains and entropy rate.

Full-or-part-time: 12h 30m
Theory classes: 4h
Self study : 8h 30m

Point-to-Point Information Theory

Description:
Channel coding, packing lemma, channel coding with input cost, Gaussian channel, lossless source coding, lossy source coding, covering lemma, quadratic Gaussian source coding.

Full-or-part-time: 37h 30m
Theory classes: 12h
Self study : 25h 30m

Distributed lossless compression

Description:
Outer bound of the optimal rate region, Slepian-Wolf Theorem, Achievability proof of the Slepian-Wolf Theorem.

Full-or-part-time: 9h 23m
Theory classes: 3h
Self study : 6h 23m

Multiple Access Channels, Broadcast Channels and Interference Channels

Description:
Discrete Memoryless Multiple Access channel, broadcast channel and interference channel, simple capacity region bounds, time sharing, capacity region, Gaussian Channels.

Full-or-part-time: 46h 52m
Theory classes: 15h
Self study : 31h 52m

The information bottleneck.

Description:
The Information Bottleneck definition, infomation-theoretic problem formulation, Lagrange Dual and Information Bottleneck Curve. Infomation Bootleneck problem in Deep Learning, problem statement, bounding and quantizing.

Full-or-part-time: 12h 30m
Theory classes: 4h
Self study : 8h 30m

ACTIVITIES

Exercises.

Description:
Exercises to strengthen the theoretical knowledge. A set problems to be solved individually or in groups (maximum three students per group) will be available after each chapter.

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

Paper presentation.

Description:
The student will prepare a slide presentation of a journal paper of his choice related to Information Theory previously agreed with the professor. The presentation must be prepared using the provided LaTex template. Preparation of the presentation slides is mandatory but actual delivery of the presentation at the final exam day is optional. There is no final exam.

Full-or-part-time: 6h
Guided activities: 6h

GRADING SYSTEM

- Exercises (60%)
- Journal paper presentation (40%)

BIBLIOGRAPHY

Basic:
- El-Gamal, Abbas; Kim, Young-Han. Network information theory. Primera. Cambridge: Cambridge Univerisity Press, 2011. ISBN 978-1-107-00873-1.

Complementary:
- Cover, T.M.; Thomas, J.A. Elements of information theory. 2nd ed. New York: John Wiley & Sons, 2006. ISBN 978-0-471-24195-9.
- MacKay, D.J.C. Information theory, inference, and learning algorithms. Cambridge, UK ; New York: Cambridge University Press, 2003. ISBN 978-0521642989.
- Yeung, R.W. A first course in information theory. New York: Springer, 2002. ISBN 978-0306467912.