

Information Theory

Academic Year: (2023 / 2024)

Review date: 24-04-2023

Department assigned to the subject: Signal and Communications Theory Department

Coordinating teacher: KOCH , TOBIAS MIRCO

Type: Electives ECTS Credits : 6.0

Year : 1 Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Students should have a solid basis in probability and calculus, as well as pleasure with mathematics. Having taken a course on Digital Communications / Communication Theory is also helpful.

OBJECTIVES

This course teaches the fundamentals of Information Theory. Students will acquire a profound understanding of:

- Information-theoretic quantities, such as entropy, Kullback-Leibler divergence, and mutual information.
- Mathematical tools commonly used in Information Theory, such as Jensen's inequality.
- The concepts and fundamental theorems of data compression.
- The application of Information Theory in Machine Learning.

DESCRIPTION OF CONTENTS: PROGRAMME

This course teaches the fundamentals of Information Theory. The topics covered in this course are as follows:

- 1) Fundamental quantities and concepts in Information Theory: entropy, Kullback-Leibler divergence, mutual information and Jensen's inequality.
- 2) Lossless data compression: uniquely decodable and instantaneous source codes, Kraft's inequality, analysis of the optimal codeword length, Huffman codes, and universal compression.
- 3) Information theory and machine learning: Generalization error, empirical risk minimization, classical statistical learning generalization guarantees, information theoretic generalization bounds.

LEARNING ACTIVITIES AND METHODOLOGY

Lectures:

The basic concepts will be mainly taught at the blackboard. We will follow closely the book "Elements of Information Theory" by Cover & Thomas (see Basic Bibliography).

Exercises:

In order to deepen the understanding of the taught material, every two weeks students have to hand in the solutions to a set of problems. These solutions will be graded from 1 to 10, the average grade over the whole semester will constitute part of the grade of the continuous assessment.

ASSESSMENT SYSTEM

Continuous assessment:

Every two weeks, each student has to hand in the solutions to a set of problems. These solutions will be graded from 1 to 10, the average grade over the whole semester will constitute 40% the grade. Furthermore, at the end of the semester, there will be an exam, where each student is tested on the material taught in this course. The exam will constitute 60% of the grade.

Convocatoria extraordinaria:

There will an exam, where each student is tested on the material taught in this course.

% end-of-term-examination:	0
% of continuous assessment (assignments, laboratory, practicals...):	100

BASIC BIBLIOGRAPHY

- Thomas M. Cover and Joy A. Thomas Elements of Information Theory, Second Edition, 2006

ADDITIONAL BIBLIOGRAPHY

- Abbas El Gamal and Young-Han Kim Network Information Theory, First Edition, 2011
- Imre Csiszár and János Körner Information Theory: Coding Theorems for Discrete Memoryless Systems, Second Edition, 2011
- Robert G. Gallager Information Theory and Reliable Communication, First Edition, 1968