ECM5104:

Information Theory

Fall Semester 2015
Prof. Dr. Stefano Rini

Brief

Instructor: Stefano Rini
Office: Engineering Building 4, Room 729
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Lecture: Tuesday 13:20-16:20
in room B07, Engineering Building 4.

Office Hours: Tuesday and Thursday 15:20-16:20
in room ED716a, Engineering Building 4.

Pre-req. Probability (UEE2102) and Linear Algebra (UEE1061) or permission of the instructor

Grading: 20 % Final Exam
20 % Midterm Exam
20 % Homework
20 % Quiz
10 % Presentations
10 % Class participation

Syllabus

Course Objectives

The course covers the fundamentals of information theory, a mathematical theory developed to quantify the amount of information contained in a random source and study how such information can be manipulated. While studying these topics, we will also develop some basic data compression and data transmission algorithms.

The course will cover approximately the following topics:

- Shannons Measure of Information
    - entropy
    - mutual information
    - relative entropy

    - Shannons Measure of Information
        * entropy
        * mutual information
        * relative entropy
    - Source coding: how to compress data efficiently?
        * Kraft inequality
        * source coding theorem for a single random variable
        * Shannon-type codes
        * Fano code
        * Huffman code
        * arithmetic coding
        * Tunstall code
        * source coding theorem for a sources with memory
        * adaptive Huffman coding
        * universal codes: Elias - Willems coding,
        * LempelZiv coding
    - Asymptotic Equipartition Property (AEP)
    - KarushKuhnTucker (KKT) conditions
    - Gambling and Horse Betting
    - Channel coding: how to transmit data reliably?
    - Fano's inequality and data processing lemma
    - computing capacity
    - error exponents
    - joint source and channel coding
    - Continuous random variables and differential entropy
    - Gaussian Channel:
        * channel coding theorem for the Gaussian channel
        * bandlimited AWGN channel

* parallel Gaussian channels

The first half of the course will focus on a deterministic description of a communication systems while, in the second part, we will focus the random aspects of a transmission system.

We hope that a student who finishes the course will be able to better understand the principles underlying all state-of-the-art communication systems and the difficulties encountered when designing and trying to improve upon them.

Textbook

The course will follow a widely adopted textbook

- G. Proakis and M. Salehi, *Essentials of Communication Systems Engineering*, Prentice-Hall, 2005.

This book essentially presents the same material as

- S. Haykin and M. Moher, *Communication Systems*, 5th Edition, Wiley, 2010,

with some differences in the notation and the presentation.

Other Recommended textbooks are:

- G. Proakis and M. Salehi, *Digital Communications*, 5th Edition, McGraw-Hill Science, 2007.
- A. Lapidoth , *A Foundation in Digital Communication* Cambridge University Press, 2009.
- B. P. Lathi, Modern Digital and Analog Communication Systems, 3rd Edition, Oxford University Press, 1998.

Exercises

Every week, a new homework assignment will be posted on the course website. This homework will consist of several problems that need to be solved at home and handed in during the class of the following week. Each homework will also contain a numerical simulation exercise which must be solved using MATLAB or a similar mathematical simulation software.

A model solution will be published online after the homework has been collected.

To pass the course you need to hand in at least 10 exercises.

Exams

There will be one mid-term and one final exam, each lasting two hours and covering approximatively three chapters.

Special Remarks

The lecture will be held in English.