Information Theory

Fall Semester 2012/2013

Prof. Dr. Stefan M. Moser

Syllabus

http://moser.cm.nctu.edu.tw/nctu/it/

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1 Website

There is a website which is always kept up-to-date:

http://moser.cm.nctu.edu.tw/nctu/it/

You will find there all necessary information and current announcements about this course. All handouts and exercises that are handed out during classes will also be available for download on this page. Note that while the website is available worldwide, most documents can only be downloaded from within the National Chiao Tung University (NCTU) and the National Tsing Hua University (NTHU).

2 Course Objective

This course is an introduction to Information Theory. We will cover the most important results concerning data compression and reliable communication over a communication channel. The course will follow the following schedule:

- Introduction and basic definitions:
  - 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
  - Shannon code
  - Fano code
  - Huffman code
  - source coding theorem for a discrete memoryless source
  - arithmetic coding
  - Tunstall code
  - source coding theorem for a sources with memory

  - adaptive Huffman coding
  - universal codes: Elias-Willems coding, Lempel-Ziv coding
- Tools in information theory:
  - Asymptotic Equipartition Property (AEP)
  - Karush-Kuhn-Tucker conditions
- Gambling and Horse Betting
- Channel coding: how to transmit data reliably?
  - Fano's inequality and data processing lemma
  - channel coding theorem for a discrete memoryless channel
  - computing capacity
  - 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
- Brief overview over cryptography

We hope that a student who finishes the course will be able to understand the basic principles underlying any communication or data storage system.

3 Prerequisites

The following lectures/topics are recommended:

- Probability
- once more Probability
- Principles of Communication Engineering I and II (preferably, but not necessary)
- joy in math and engineering

4 Instructor

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5 Time and Place

There will be two lectures per week:

- Monday, 13:20–15:10 (EF), Engineering Building IV, Room B21 (ED021)
- Wednesday, 10:10–12:00 (CD), Engineering Building IV, Room B21 (ED021)

The course starts on Monday, 17 September, and finishes on Wednesday, 16 January. For a more detailed program see the above mentioned website. Note that the second hour on Wednesday usually is reserved for exercises.

6 Office Hours

NCTU requests that every teacher offers two hours per week where students may come to ask questions. I will, of course, also do so. The exact time will be announced once it is decided.

However, we would like to encourage you to show up in the teacher's or teaching assistant's office at any time in case you have questions about the class or related subjects. Moreover, we are always available during and after classes and particularly in the second hour on Wednesday (the "exercise" lecture).

7 Textbook

The course will follow my own lecture notes:

- Stefan M. Moser: *Information Theory (Lecture Notes)*, version 2, fall semester 2012/2013.

This script will be distributed free of charge to all registered students of the course during the first week of the semester, and it is available online for download.

Further references and recommended readings:

- Claude E. Shannon: "A mathematical theory of communication," Bell System Technical Journal, vol. 27, pp. 379-423 and 623-656, July and October 1948.
- James L. Massey: "Applied Digital Information Theory I and II," lecture notes, Swiss Federal Institute of Technology (ETH), Zurich, Switzerland.
- Thomas M. Cover and Joy A. Thomas: *Elements of Information Theory,* second edition, Wiley, 2006.
- Robert G. Gallager: *Information Theory and Reliable Communication,* Wiley, 1968.
- Po-Ning Chen and Fady Alajaji: "Lecture Notes in Information Theory," Volume I & II, National Chiao Tung University (NCTU), Hsinchu, Taiwan.
- Raymond W. Yeung: *A First Course in Information Theory,* Kluwer Academic Publishers, 2005.

8 Exercises

Every week, an exercise will be distributed in class and also made available online for download. This exercise will consist of several problems that need to be solved at home and handed in during the class of the following week. A model solution will be distributed and made available online afterwards.

We believe the exercises to be extremely important and crucial to the understanding of the course. They also serve as a preparation for the mid-term and final exams and we therefore highly recommend to solve them. **To pass the course you need to hand in at least 10 exercises.**

9 Exams

There will be one mid-term and one final exam. Both exams are going to last three hours and be open-book. Details about the covered material in the mid-term exam will be published in due time. The final exam will cover everything taught in class.

10 Grading

The grade will be an average of

- the homework and class participation (15%),
- the mid-term exam (35%), and
- the final exam (50%).

The grade of the homework will not be based on the correctness of the answers, but rather on the effort the student shows in trying to solve them. Moreover, I will try to reward students who participate actively in class.

This course is worth 3 credits.

11 Special Remarks

The lecture will be held in English.