ECM 5112: Advanced Topics in Information Theory

Spring Semester 2014
Prof. Dr. Stefano Rini

<div align="center">Brief</div>

Website: http://moser.cm.nctu.edu.tw/rini/atit

Instructor: Stefano Rini
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Lecture: Tuesday 13:20-14:10, 14:20-15:10
Thursday 14:20-15:10
in room EE207, Engineering Building 5.

Office Hours: Tuesday and Thursday 15:20-16:20
in room ED729, Engineering Building 4.

Pre-req. Probability (UEE2102) and Information Theory
(ECM5104) or permission of the instructor

Grading: 40 % Final Take-Home Exam
20 % Midterm Take-Home Exam
20 % Homework and class participation
20 % Research project

<div align="center">Syllabus</div>

Course Objectives

This course is an advanced course in information theory. Based on the theory we have learned in the course *Information Theory* we will continue to explore the most important results concerning data compression and reliable communication over a communication channel. We will talk about multiple-user communication and lossy compression schemes. The course will cover approximately the following topics:

- Method of types.

- Strong typicality.

- Rate distortion theory.

- Multiple description.

- Capacity Cost

- Rate distortion with side-information (Wyner–Ziv).

- Distributed lossless data compression (Slepian–Wolf).

- Multiple-access channel (MAC).

- Transmission of correlated sources over a MAC.

- Channels with noncausal side-information (Gel'fand–Pinsker).

- Broadcast channel.

- Interference channel.

- Cognitive interference channel

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 them.

Textbook

The course will follow the lecture notes from Prof. Moser and Prof. Kramer:

- Stefan M. Moser: *Advanced Topics in Information Theory (Lecture Notes)*, version 2.1, spring semester 2013.

- Gerhard Kramer: *Topics in Multi-User Information Theory*, Foundations and Trends in Communications and Information Theory, vol. 4, nos. 4-5, pp. 265-444, 2007.

These lecture notes are available online for download at the two following links respectively

- http://moser-isi.ethz.ch/docs/atit/_script/_v21.pdf

- http://www.lnt.ei.tum.de/fileadmin/staff/kramer/Papers/kramerNOW07-2.pdf

Recommended textbooks are:

- Thomas M. Cover and Joy A. Thomas: *Elements of Information Theory,* second edition, Wiley, 2006.

- Abbas El Gamal and Young-Han Kim: *Network information theory*, first edition, Cambridge University Press, 2011.

Further references are:

- Robert G. Gallager: *Information Theory and Reliable Communication,* Wiley, 1968.

- Imre Csiszár, János Körner: *Information Theory: Coding Theorems for Discrete Memoryless Systems,* 3rd edition, Akademiai Kiado, Budapest.

- Po-Ning Chen and Fady Alajaji: "Lecture Notes in Information Theory," Volume I & II, National Chiao Tung University (NCTU), Hsinchu, Taiwan.

- James L. Massey: "Applied Digital Information Theory I and II," lecture notes, Swiss Federal Institute of Technology (ETH), Zurich, Switzerland.

- Raymond W. Yeung: *A First Course in Information Theory,* Kluwer Academic Publishers, 2005.

Website

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

$$\text{http://moser.cm.nctu.edu.tw/rini/atit}$$

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

Exercises

Every week, an exercise will be distributed in class. 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 handed out 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 exams and we therefore highly recommend to solve them. **To pass the course you need to hand in at least 10 exercises.**

Exams

There will be one mid-term and one final exam. The exams will be take-home exams and three days will be given to solve the problems therein.

Final Project

Participants shall review, hand in a report on, and give a short presentation on a recent research paper on multi-terminal information theory. The choice of paper shall be agreed upon together with the instructor. Students may decide to work in a group of up to three people.

Special Remarks

The lecture will be held in English.