ENEE 729D: Topics in Communication: Information Theory

Information Geometry and Multiuser Information Theory

Fall 2009

Time/Venue

TuTh 3:30 – 4:45 pm
Room CSI 1121

Instructor

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Office hours

Tu Th 2:00 – 3:15 pm
Also by appointment.

Course website

http://www.ece.umd.edu/class/enee729D

Course outline

This course will cover two broad areas in information theory: information geometry and multiuser information theory.

We shall begin with a development of the geometry of Kullback-Leibler divergence, including the notions of I-projection, f-divergence and Rényi entropy. A key concept will be that of the projection of a probability distribution onto a linear family of distributions, leading to an iterative algorithm for finding the minimum divergence between two convex sets of distributions. As an example, the EM algorithm for maximum-likelihood estimation will be studied.

The second topic deals with the notions of source coding (data compression) and channel coding for a communication situation with multiple senders or receivers; the issues of interference, cooperation and feedback will be addressed. Particular emphasis will be placed on: Slepian-Wolf multiterminal data compression; Wyner-Ziv rate distortion; the multiple-access channel, with many transmitters and a single receiver; and the broadcast channel, with a single transmitter and multiple receivers. Recent developments in cooperation and correlation in multiuser models will also be considered. Time permitting, connections between multiuser information theory and information theoretic multiuser secrecy generation will be treated.

Prerequisites

ENEE 620 (Random processes), ENEE 621 (Estimation and detection) and ENEE 627 (Information theory), or permission of the instructor.

Course outline

I. Information geometry

1. Kullback-Leibler divergence, hypothesis testing, Sanov's theorem.
2. Information geometry, f-divergence, Rényi entropy.
3. I-projection onto linear families, iterative computation.
4. Iterative algorithm for finding the minimum divergence between two convex sets of distributions, the EM algorithm.

II. Multiuser information theory

(`Content might vary according to students' prior knowledge.`)

1. Slepian-Wolf multiterminal data compression.
2. Wyner-Ziv rate distortion.
3. Multiple-access channel – discrete alphabet and Gaussian models.
4. Broadcast channel – discrete alphabet and Gaussian models.
5. Relay and interference channels, the "deterministic" approach.
6. Information theoretic security.

References

There is no required or recommended text. The course material will be drawn largely from a selection of books and journal articles.

The following two standard books will serve as the main references for *preparatory material* on information geometry and multiuser information theory.

T.M. Cover and J. Thomas, *Elements of Information Theory*, Wiley, New York, 1991.

I. Csiszár and J. Körner, *Information Theory: Coding Theorems for Discrete Memoryless Systems*, Academic, New York, 1981. (`An electronic copy will be posted at the course website.`)

The following articles pertinent to information geometry will be posted at the course website.

I. Csiszár and G. Tusnády, "Information geometry and alternating minimization procedures," *Statistics and Decisions*, Suppl. Issue 1, pp. 205-237, 1984.

I. Csiszár and P. Shields, "Information Theory and Statistics: A Tutorial," *Foundations and Trends in Communications and Information Theory*, Volume 1, Issue 4, 2004.

Additional material will drawn from recent articles in the *IEEE Transactions on Information Theory, IEEE Transactions on Communications, and IEEE Journal on Selected Areas in Communications.*

Course grade

The course grade will be determined on the basis of a student's performance in (i) a midterm assessment of progress on a term project, and (ii) a final assessment of the completed term project. A term project will consist of work on an assigned topic involving research on open issues combined with a comprehensive oral presentation, and will *not* be of the nature of a survey of existing literature. (It is likely that the oral presentations will take place in the *Information and Coding Theory Seminar Series*; see http://www.ece.umd.edu/Academic/seminars/infocoding/.)

Problems to be addressed in a term project will be assigned at the end of approximately four (4) weeks into the semester. Final project reports are due no later than the last day of examinations.