Math 474/874 - Information Theory

Fall Term 2008

Instructor:	Fady Alajaji – Jeffery Hall 402 Phone: 533-2423 – E-mail: fady@mast.queensu.ca Web page: http://www.mast.queensu.ca/∼fady/
Course Web Site:	http://www.mast.queensu.ca/∼math474 All homeworks and announcements will be posted on this site
Time/Place:	Slot 1: Monday 8:30, Tuesday 10:30, Thursday 9:30 Jeffery Hall, Room 110
Office Hours:	Friday: 9:30 - 11:30, or by appointment
Text:	Class Notes T.M. Cover - J.A. Thomas, *Elements of Information Theory*, Second Edition, John Wiley & Sons, 2006
Grading:	Homeworks: 10% – Midterm Exam: 30% – Final Exam: 60% Undergraduate students enrolled in MATH-474 will receive a reduced load in the homeworks and exams
Note:	The Midterm Exam is tentatively scheduled for *Wednesday, November 5, 2008*

Course Outline

The reliable transmission of information bearing signals over a noisy communication channel is at the heart of what we call communication. *Information theory* – founded by Claude E. Shannon in 1948 – provides a mathematical framework for the theory of communication; it describes the *fundamental limits* to how efficiently one can encode information and still be able to recover it with negligible loss. This course will examine the basic concepts of this theory. What follows is a list of topics to be covered.

1. *Shannon's Measures of Information:* entropy, divergence, mutual information; properties of information measures; the data processing theorem; Fano's inequality.

2. *Fundamentals of Fixed-Length Lossless Source Coding (Data Compression):* discrete memoryless sources, asymptotic equipartition property (AEP), block or fixed-length coding, fixed-length source coding theorem for discrete memoryless sources; entropy rate of stationary sources with memory, Markov sources, stationary ergodic sources, fixed-length source coding theorem for stationary ergodic sources; source modeling and redundancy.

3. *Fundamentals of Variable-Length Lossless Source Coding:* variable-length encoding, unique decodability, Kraft inequality, prefix codes, variable-length source coding theorem for discrete memoryless sources and for stationary sources with memory; Shannon-Fano code; construction of optimal variable-length codes: Huffman codes.

4. *Fundamentals of Channel Coding:* discrete memoryless channels, channel capacity and properties; noisy channel coding theorem for discrete memoryless channels; the lossless joint source-channel coding theorem.

5. *Information Theory for Continuous Alphabet Systems:* differential entropy, divergence and mutual information; differential entropy of the multivariate Gaussian distribution; AEP for continuous alphabet memoryless sources, capacity of discrete-time and band-limited continuous-time memoryless Gaussian channels; parallel Gaussian channels and waterfilling.

6. *Rate-Distortion Theory:* (time permitting) lossy data compression; discrete memoryless sources, rate-distortion function and its properties; rate-distortion theorem; the lossy joint source-channel coding theorem.

References:

- R. Gallager, *Information Theory and Reliable Communication*, John Wiley, 1968.
- R. Blahut, *Principles and Practice of Information Theory*, Addison Wesley, 1987.
- R. Yeung, *A First Course in Information Theory,* Kluwer, 2002.

Policy for Missing Exams: There will be no makeup exams. If a student misses the midterm due to severe illness or a personal tragedy, then the final exam will count towards 90% of the student's mark.

Students with Special Needs: Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability or health consideration that may require accommodations, please feel free to approach me and/or the Accessibility Services Office as soon as possible. The Accessibility Services staff are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations. The sooner you let them and me know your needs, the quicker we can assist you in achieving your learning goals in this course.