Math 474/874 - Information Theory

Fall Term 2006

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Course Web Site:	http://www.mast.queensu.ca/~math474 All homeworks and announcements will be posted on this site
Time/Place:	Tuesday 9:30, Wednesday 8:30, Friday 10:30 Jeffery Hall, Room 110
Office Hours:	Thursday: 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 8, 2006*

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.