Information Theory EE634

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1. Syllabus
   (a) Quantitative Study of Information (Basics)
      - Random Variables, Entropy and Mutual Information
      - Random Processes and Entropy Rate
      - Important Relationships, Rules and Inequalities
   (b) Information Sources and Source Coding
      - Source Modeling
      - Asymptotic Equipartition Principle and Source Coding
      - Data Compression: LZW Algorithm
   (c) Information in Constrained Sequences
      - Runlength-limited (RLL) Sequences
      - Capacity of RLL Sequences
      - RLL Codes and Decoders
   (d) Information Transmission
      - Channel Modeling: DMCs, AWGN Channels
      - Channel Capacity Calculation
      - Channel Coding Theorem
   (e) Principles for Approaching Capacity in Practice (approximately last 6 weeks will be spent on this part)
      - Memoryless Channels: TCM, Multilevel Coding, Turbo Principle
      - Channels with ISI: Equalization, Waterfilling, Multicarrier Modulation
      - Fading Channels: Ergodic and Outage Capacity, MIMO Systems, Bit-interleaved Coded Modulation

2. Reading Material
   - Textbook: Elements of Information Theory by Thomas Cover and Joy Thomas
   - Recommended Text: Information Theory and Reliable Communication by Robert Gallager
   - Recommended Text: Applied Coding and Information Theory for Engineers, Richard B. Wells (Low price edition available)
   - References:
      (a) "Modulation and coding for linear Gaussian channels", G. D. Forney; G. Ungerboeck; IEEE Transactions on Information Theory, Volume: 44, Number: 6, October 1998, Pages:2384 - 2415
      (b) "Trellis-coded modulation with redundant signal sets Part I: Introduction and Part II: State of the art", Ungerboeck, G.; IEEE Communications Magazine, Volume: 25, Issue: 2, Feb 1987, Pages:5 - 21
      (c) "Multilevel codes: theoretical concepts and practical design rules", Wachsmann, U.; Fischer, R.F.H.; Huber, J.B.; IEEE Transactions on Information Theory, Volume: 45, Number: 5, July 1999, Pages:1361 - 1391
      (d) IEEE Communications Magazine, Aug 2003, Pages: 100 - 140
      (e) IEEE Journal on Selected Areas in Communications, Special Issue on the Turbo Principle, May 2001

(f) "Multicarrier modulation for data transmission: an idea whose time has come", Bingham, J.A.C.; IEEE Communications Magazine, Volume: 28, Issue: 5, May 1990, Pages:5 - 14

(g) "Bit-interleaved coded modulation", Caire, G.; Taricco, G.; Biglieri, E.; IEEE Transactions on Information Theory, Volume: 44, Issue: 3, May 1998, Pages:927 - 946

3. Assignments
   - A few problems will be assigned every week as assignment.
   - Though the assignments need not be submitted, they are essential to gain a good understanding of the subject. By the way, you might find them useful for the end semester exam.
4. Projects (to be implemented in C, MATLAB or SCILAB)
   - Small Project 1: AEP and Source Coding (10%)
   - Small Project 2: (d,k) Constrained Sequences (10%)
   - Small Project 3: Capacity of DMCs (10%)
   - Final Project: Capacity of M-PAM over AWGN (20%)
5. Final Exam (50%)
   - This will most probably be an open-everything, take-home exam. Of course, no consultation or cooperation of any kind is permitted.
6. Remarks about projects: I cannot over-emphasize the importance of the projects in this course. The projects can be done either individually or as a group of two persons. The code (C, MATLAB or SCILAB) and a 1-page report with the results of the project will have to be submitted on the assigned due date by email. Limited consultations are permitted, but each group (or individual) will have to write their own code and explicitly name the consultants in the report.