EEL 6550 - Error Control Coding

Dr. John M. Shea

Spring 2008

Course web site: `http://wireless.ece.ufl.edu/eel6550`
Pre-requisite: EEL 5544 Noise in Linear Systems, basic knowledge of digital communications
Meeting Time: 7th period (1:55-2:45) MWF
Meeting Room: BEN 328
E-mail: jshea@ece.ufl.edu
Office: 439 New Engineering Building
Phone: (352)846-3042
Office hours: To be announced
Final Exam: Thurs., May 1st, 10 AM – 12 PM, BEN 328
Textbook: Shu Lin and Daniel J. Costello, Jr., *Error Control Coding: Fundamentals and Applications*, 2nd ed., Prentice Hall, 2004 (ISBN 0130426725).
References:

- Stephen B. Wicker, *Error Control Systems for Digital Communication and Storage*, Prentice Hall, 1995 (ISBN 0-13-200809-2).
- Robert J. McEliece, *Finite Fields for Computer Scientists and Engineer*, Kluwer Academic Publishers, 1987 (ISBN 0-89838-191-6).
- Robert G. Gallager, *Low-Denisty Parity-Check Codes*, MIT Press, 1963.
- John D. Spragins, Joseph L. Hammond, and Krzysztof Pawlikowski, *Telecommunications: Protocols and Design*, Addison-Wesley, 1991 (contains good information on CRC codes in Chapter 6).
- Branka Vucetic and Jinhong Yuan, *Turbo Codes: Principles and Applications*, Kluwer Academic Publishers, 2000 (ISBN 0-7923-7868-7).
- Todd K. Moon, "Error Correction Coding," John Wiley & Sons, 2005.

Course Topics

- Introduction
  - Data transmission
  - Types of error control
  - Types of codes
  - Binary modulation
  - Maximum likelihood decoding
  - Types of errors

- Abstract Algebra
  - Groups
  - Fields
  - Binary field arithmetic
  - Construction of Galois Field GF(2^m)
  - Properties of Galois Field GF(2^m)
  - GF(2^m) arithmetic
  - Vector spaces over fields
  - Matrices over fields
- Block Codes
  - Linear Block Codes
    - Encoding
    - Decoding
    - Syndrome and error detection
    - Distance and error-detection and -correction properties
    - Array and syndrome decoding
    - Probability of error
    - Hamming codes
    - Modified linear codes
  - Cyclic codes
    - Properties
    - Encoding and decoding
    - CRC codes
  - Reed-Muller codes
    - Majority logic decoding
  - Low-Density Parity-Check Codes
    - Belief propagation/Gallagher Decoding
  - BCH and Reed-Solomon Codes
  - Block Code Performance Analysis
- Convolutional and Related Codes
  - Linear, Nonrecursive Convolutional Codes
    - Encoding
    - Properties
    - Graphs, state diagrams, and trellises
    - Distance properties
    - Maximum likelihood (Viterbi) decoding
    - Performance analysis
    - Punctured codes

  - Turbo Codes
    * Recursive, systematic convolutional codes
    * MAP decoding
    * Distance properties
    * Performance bounds
    * Interleaver design
  - Trellis Codes
    * M-ary signaling
    * Set partitioning
    * Distance properties
    * Multiple TCM
    * Decoding and performance

Goals and Objectives: Upon completion of this course, the student should be able to

- list advantages and disadvantages of ARQ and FEC
- select an appropriate error control technique and/or code for a communication system
- compare the performance of different error control schemes
- implement decoders for block, convolutional, trellis, and turbo codes

Grading: Grades are based 15% on *homework projects* that consist of developing software for error-control coding and using tools such as PARI and MATLAB, 25% on one *in-class exam*, 15% on *class participation*, 20% on a research paper presentation, and 25% on a *final exam*. $> 90\%$ is guaranteed an A, $> 80\%$ is guaranteed a B, etc. Homework projects will be accepted late one time, with an automatic 25% reduction in grade.

Attendance: Attendance is not mandatory, however, attendance does contribute to the class-participation grade. In addition, students are expected to know all material covered in class, even if it is not in the book. If an exam must be missed, the student must see the instructor and make arrangements in advance unless an emergency makes this impossible. Approval for make-up exams is much more likely if the student is willing to take the exam early.

Academic Honesty Policy: The student body has adopted a University of Florida Honor Code to emphasize the importance of academic integrity. In adopting this Honor Code, the students of the University of Florida recognize that academic honesty and integrity are fundamental values of the University community. Students who enroll at the University commit to holding themselves and their peers to the high standard of honor required by the Honor Code. Any individual who becomes aware of a violation of the Honor Code is bound by honor to take corrective action. A student-run Honor Court and faculty support are crucial to the success of the Honor Code. The quality of a University of Florida education is dependent upon the community acceptance and enforcement of the Honor Code.

The Honor Code: We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity.

On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied:

"On my honor, I have neither given nor received unauthorized aid in doing this assignment."

Collaboration is not permitted on *homework projects*. Homework problems that do not involve computer work will be assigned but not collected. Students are expected to do all homework problems and quizzes may be used to test material from the homeworks. Collaboration is encouraged on the homework problems.

Accommodations for Students with Disabilities: Students requesting classroom accommodation must register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor when requesting accommodation.