CS 296.1 Error Correcting Codes

Lecture 1: Binary Linear Block Codes, Syndrome Decoding, Hamming Distance and Maximum Likelihood Decoding, Perfect Codes, Connections to Design of Experiments

Lecture 2: The Fast Hadamard Transform, Walsh Functions and First Order Reed Muller Codes

Lecture 3: Fourier Analysis in the Binary World I, Equiangular Lines, Mutually Unbiased Bases

Lecture 4: The Binary Golay Code

Lecture 5: Binary Convolutional Codes, Viterbi Algorithm, Punctured Codes, Algebraic Approach to Convolutional Codes, Bandwidth Efficient Communication

Lecture 7: Magnetic Recording Channel – Mathematical Model, Peak Detection and Run Length Limited Codes, Constrained Coding, Partial Response and Gains over Threshold Detection

Lecture 8: Digital Fountains – Amazing Codes for Correcting Erasures

Lecture 9: Finite Fields**,** Euclid's Algorithm and Euclidean Domains**,** Prime Factorization in Euclidean Domains

Lecture 10: Existence of Finite Fields, Multiplicative Orders of Field Elements Minimal Polynomials of Conjugate Roots

Lecture 11: Uniqueness of Finite Fields, Lattice of Subfields of a Finite Field

Lecture 12: How to Solve Quadratic Equations over Finite Fields, Decoding 2-Error Correcting BCH Codes, Bit Serial Multiplication

Lecture 13: Reed Solomon Codes

Lecture 14: The Berlekamp-Massey Algorithm

Mid-Semester Break

Lecture 15: Introduction to Quantum Computing

Lecture 16: Quantum Error Correction

Lecture 17: Introduction to Compressive Sensing, Sparsity, Johnson-Lindenstrauss, Restricted Isometry Property

Lecture 18: Sparse Approximation

Lecture 19: Sparse Reconstruction, Basis and Matching Pursuit

Lecture 20: New Developments in Compressed Sensing

Lecture 21: Codes and Lattices, Rotations and Changes of Scale

Lecture 22: Decoding Lattices, Addressing Constellations, Voronoi Constellations, Opportunistic Secondary Channels, Second Moment Calculations

Lecture 23: Non-Equiprobable Signaling, Constellation Expansion Ratio

Lecture 24: Shaping and Coding Gain

Lecture 25: Coding for Channels with Memory

Lecture 26: Compression of Sources with memory

Lecture 27: Wireless Channels, Precoding

Lecture 28: Application of Lattices to Wireless Precoding

Recommended Books

K.A. Schouhamer Immink, *Codes for Mass Data Storage Systems*, Shannon Foundation Publishers, The Netherlands.

Richard Blahut, *Algebraic Codes for Data Transmission*, Cambridge University Press, 2003.

David J.C. MacKay*, Information Theory, Inference and Learning Algorithms*, Cambridge University Press, 2003

R.J. McEliece, *Finite Fields for Computer Scientists and Engineers*, Kluwer, 1987