School of Mathematics

Course 373 — Error Correcting Codes   2005-06
(JS & SS Mathematics)

Lecturer: Dr. M. Purser & Dr. T.G. Murphy

Requirements/prerequisites:

Duration: 21 weeks

Number of lectures per week: 3

Assessment:

End-of-year Examination: 3-hour end of year exam

Description: The course will be in two parts: Dr Purser will lecture on Error Correcting Codes for 2 hours per week, and Dr Murphy will lecture on Finite Fields for 1 hour per week.

   The course on Finite Fields can be found on the web at `http://www.maths.tcd.ie/pub/Maths/Courseware/FiniteFields/`.

   Outline of Dr Purser's course on Error Correcting Codes

1. Introduction

   - Block codes
   - Hamming distance
   - Errors: Random or Burst
   - Error-detection
   - Probability of Error-detection
   - Error-correction
   - Probability of successful Error-correction
   - Sphere-packing Bound
   - Shannon's Theorem on Capacity

2. Linear Codes

   - Minimum Weight
   - Generator Matrix
   - Null Matrix
   - Standard Array
   - Syndromes
   - Hamming Codes
   - Perfect Codes
   - Varshamov-Gilbert Bound

- Plotkin Bound
- Non-binary linear Codes
- Erasures

3. Modulation

- Frequency Shift Keying (FSK)
- Phase Shift Keying (PSK)
- Differential PSK (DPSK)
- Symbols and Bits
- Gray Coding
- Noise. Additive White Gaussian Noise (AWGN) and bit errors
- Signal/Noise Ratios (SNRs)
- Shannon for Continuous AWGN Channel
- Shannon Limit
- Other Modulations

4. Cyclic Codes

- Generating Polynomial $g(x)$ of the Ideal
- Systematic Cyclic Codes
- Roots of $g(x)$ and the Null Matrix
- Error-detection with cyclic codes
- Weight distributions
- Shortened Cyclic Codes
- Feed-back shift registers (FBSRs)
- Error-correction with Cyclic Codes, the Syndrome
- Kasami's Method
- Non-binary Cyclic Codes

5. Information Theory

- Information and Entropy
- Immediate Codes and Compression
- Mutual Information
- Capacity
- The Binary Symmetric Channel (BSC)

6. BCH Codes

- Roots of BCH Codes
- Minimum Polynomials
- Examples
- Error-correction of BCH Codes
- Berlekamp-Massey Algorithm
- Non-binary BCH Codes
- Reed-Solomon Codes
- Weight Distribution and the Probability of Incorrect Error-Correction

7. Convolutional Codes

- Trellis codes
- Viterbi Decoding
- Linear Convolutional Codes
- Catastrophic Codes
- Analysis of Convolutional Codes
- Error-correction
- Soft-decision Decoding
- Sequence, Feedback and Threshold Decoding

8. Trellis Code Modulation (TCM)

- Symbols not bits
- Distance and SNRs
- PSK Example
- Phase Invariance
- Phase/Amplitude Modulation and TCM
- Example

9. Code Division Multiple Access (CDMA)

- Use of Spectrum
- Maximum Length Sequences
- CDMA and Third Generation Mobile Telephony

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