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Timing and Structure
Michaelmas Term. 16 lectures. Assessment: 100% exam

Aims
The aims of the course are to:

- To introduce students to the principles of information theory, data compression, and error-correction, which form the foundations of modern communication and information processing systems.

Objectives
As specific objectives, by the end of the course students should be able to:

- Explain why entropy and channel capacity arise as fundamental limits for data compression and transmission, respectively
- Understand and implement basic compression algorithms such as Huffman coding and Arithmetic coding
- Encode and decode information using simple linear block codes
- Implement decoders for error-correcting codes such as LDPC codes

Content

Information Theory and Data Compression (11L)

1. Probability fundamentals; Definitions of entropy, joint entropy, conditional entropy: interpretations as measures of uncertainty

2. Noiseless source coding theorem; Significance of entropy as the fundamental limit of compression
3. Bounds on code length for lossless data compression

4. Practical compression algorithms: Huffman coding, Arithmetic coding

5. Relative Entropy, Mutual Information: Properties and some applications

6. Discrete Memoryless Channels and Channel Capacity

7. The channel coding theorem: Random Coding and the direct coding theorem; Fano's inequality and the converse theorem

8. The additive white Gaussian noise (AWGN) channel and its capacity

Channel Coding (Error-correcting codes) (5L)

1. Introduction to block codes; Linear block codes

2. Representing a linear code using a factor graph; Sparse-graph codes

3. Message passing decoding of sparse-graph codes for binary erasure channels

4. The Belief-Propagation (BP) algorithm; BP decoding of sparse-graph codes for general binary input channels

Further notes
This module will be of interest to anyone who wishes to understand how information can be mathematically modelled, measured, compressed, and transmitted. Though not a pre-requisite for 3F4, 3F7 provides a good foundation for further study of communication.

Booklists
The following are useful references:


**Examination Guidelines**

Please refer to [Form & conduct of the examinations](http://teaching.eng.cam.ac.uk/content/form-conduct-examinations) [3].

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**Links**
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