# Linear Block Codes

Map Decoding of Linear Block Codes, Iterative Decoding of Reed-Solomon Codes and Interactive Concatenated Turbo Coding Systems
A Transform Approach to Cascaded Linear Block Codes
A Network Linear Block Coding Approach to Selective Detect-and-forward Multi-way Relaying
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## GRETCHEN LIU

**Map Decoding of Linear Block Codes, Iterative Decoding of Reed-Solomon Codes and Interactive Concatenated Turbo Coding Systems**
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The idea of concatenating smaller codes to obtain a composite code with longer blocklength is important in block coding theory. This is because longer codes correct a larger fraction of errors than smaller codes of similar rates and relative minimum distances over a channel with independent and identically distributed errors. This thesis adopts a transform approach to the construction of such longer codes. This approach which is a

generalization of the two-dimensional discrete Fourier transform, enables the construction of two-dimensional codes (array codes) on the basis of optimizing "zero" sets in the transform domain. The algebraic structure and properties of these codes are explained on the basis of the structure of the zero sets and the relationship of these codes to cascaded codes is detailed. The class of Hyperbolic Cascaded Algebraic Geometric codes is constructed with the aid of a suitable transform. This approach also facilitates the construction of two-dimensional burst error correcting codes. A class of such codes with low redundancy is demonstrated. Finally the interplay between the transform approach and the cascade coding approach is exploited in a decoding algorithm for HCRS codes (and their extended versions) which is simpler than the existing Sakata algorithm based method for these codes. The general decoding algorithm for cascade codes is also examined from the point of view of the transform domain.

**A Transform Approach to Cascaded Linear Block Codes**

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Channel coding lies at the heart of digital communication and data storage, and this detailed introduction describes the core theory as well as decoding algorithms, implementation details, and performance analyses. In this book, Professors Ryan and Lin provide clear information on modern channel codes, including turbo and low-density parity-check (LDPC) codes. They also present detailed coverage of BCH codes, Reed-Solomon codes, convolutional codes, finite geometry codes, and product codes, providing a one-stop resource for both classical and modern coding techniques. Assuming no prior knowledge in the field of channel coding, the opening chapters begin with basic theory to introduce newcomers to the subject. Later chapters then extend to advanced topics such as code ensemble performance analyses and algebraic code design. 250 varied and stimulating end-of-chapter problems are also included to test and enhance learning, making this an essential resource for students and practitioners alike.

A Network Linear Block Coding Approach to Selective Detect-and-forward Multi-way Relaying Springer Science & Business Media

This 2006 book introduces the theoretical foundations of error-correcting codes for senior-undergraduate to graduate students.

**Near Maximum Likelihood Decoding of Linear Block Codes** Createspace Independent Publishing

Platform
Decoding of Linear Block Codes Based on Ordered StatisticsSequential Decoding of Linear Block CodesTrellises and Trellis-Based Decoding Algorithms for Linear Block CodesSpringer Science & Business Media
Coding Techniques for Linear Block Codes with Applications to Fault Identification
Cambridge University Press
For long linear block codes, maximum likelihood decoding based on full code trellises would be very hard to implement if not impossible. In this case, we may wish to trade error performance for the reduction in decoding complexity. Sub-optimum soft-decision decoding of a linear block code based on a low-weight sub-trellis can be devised to provide an effective trade-off between error performance and decoding complexity. This chapter presents such a suboptimal decoding algorithm for linear block codes. This decoding algorithm is iterative in nature and based on an optimality test. It has the following important features: (1) a simple method to generate a sequence of candidate code-words, one at a time, for test; (2) a sufficient condition for testing a candidate code-word for optimality; and (3) a low-weight sub-trellis search for finding the most likely (ML) code-word. Lin, Shu and Fossorier, Marc
Goddard Space Flight Center NAG5-931;

NAG5-2938 *Trellis Decoding of Reed Solomon and Related Linear Block Codes* Decoding of Linear Block Codes Based on Ordered StatisticsSequential Decoding of Linear Block CodesTrellises and Trellis-Based Decoding Algorithms for Linear Block Codes Linear block codes are used in modern communication and digital storage systems to combat random errors that are introduced by communication channels (e.g., telephone lines, atmosphere, and compact discs). The idea is that the redundant bits contained in each codeword of a code can be used by the receiver to recover the actual transmitted codeword or message. The process of recovering the original codeword from a corrupted version of it is called decoding. It is implemented by an algorithm located at the receiver's end. Informally speaking, a good code is one that has a high rate, that is, it does not use much redundancy to allow error correction, but it also has an efficient decoding algorithm. Therefore, finding good codes is a relevant problem in the design of communication systems. Decoding a general linear code is an NP-hard problem: The best known general decoding algorithm for linear codes, a.k.a. syndrome decoding, increases exponentially in complexity with the length of the code. The objective of the present work is to implement/analyze a statistical decoding algorithm in a robust manner that is efficient with regards to both the amount of storage space needed and computation complexity. At least for codes of lengths less than 100, it has proven to work much faster than syndrome decoding and even some well-established decoding algorithms. The application of the algorithm is mainly illustrated with quadratic residue codes. The choice was due to the fact that QR codes have a high rate, but finding efficient decoding algorithms for them is still a challenging problem.

**The Probability of Undetected Error for Linear Block Codes**

Cambridge University Press

The trellis structure of linear block codes (LBCs) is discussed. The state and branch complexities of a trellis diagram (TD) for a LBC is investigated. The TD with the minimum number of states is said to be minimal. The branch complexity of a minimal TD for a LBC is expressed in terms of the dimensions of specific subcodes of the given code. Then upper and lower bounds are derived on the number of states of a minimal TD for a LBC, and it is shown that a cyclic (or shortened cyclic) code is the worst in terms of the state complexity among the LBCs of the same length and dimension. Furthermore, it is shown that the structural complexity of a minimal TD for a LBC depends on the order of its bit positions. This fact suggests that an appropriate permutation of the bit positions of a code may result in an equivalent code with a much simpler minimal TD. Boolean polynomial representation of codewords of a LBC is also considered. This representation helps in study of the trellis structure of the code. Boolean polynomial representation of a code is applied to construct its minimal TD. Particularly, the construction of minimal trellises for Reed-Muller codes and the extended and permuted binary primitive BCH codes which contain Reed-Muller as subcodes is emphasized. Finally, the structural complexity of minimal trellises for the extended and permuted, and double-error-correcting BCH codes is analyzed and presented. It is shown that these codes have relatively simple trellis structure and hence can be decoded with the Viterbi decoding algorithm. Lin, Shu Unspecified Center NAG5-931...

Channel Coding - Linear Block Codes

Independently Published

As the demand for data reliability increases, coding for error control becomes increasingly important in data transmission systems and has become an integral part of almost all data communication system designs. In recent years, various trellis-based soft-decoding algorithms for linear block codes have been devised. New ideas developed in the study of trellis structure of block codes can be used for improving decoding and analyzing the trellis complexity of convolutional codes. These recent developments provide practicing communication engineers with more choices when designing error control systems. Trellises and Trellis-based Decoding Algorithms for Linear Block Codes combines trellises and trellis-based decoding algorithms for linear codes together in a simple and unified form. The approach is to explain the material in an easily understood manner with minimal mathematical rigor. Trellises and Trellis-based Decoding Algorithms for Linear Block Codes is intended for practicing communication engineers who want to have a fast grasp and understanding of the subject. Only material considered essential and useful for practical applications is included. This book can also be used as a text for advanced courses on the subject.

Efficient Reliability Based Decoding of Linear Block Codes

For long linear block codes, maximum likelihood decoding based on full code trellises would be very hard to implement if not impossible. In this case, we may wish to trade error performance for the reduction in decoding complexity. Sub-optimum soft-decision decoding of a linear block code based on a low-weight sub-trellis can be devised to provide an effective trade-off between error performance and decoding complexity. This chapter presents such a suboptimal decoding algorithm for linear block codes. This decoding algorithm is iterative in nature and based on an optimality test. It has the following important features: (1) a simple method to generate a sequence of candidate code-words, one at a time, for test; (2) a sufficient condition for testing a candidate code-word for optimality; and (3) a low-weight sub-trellis search for finding the most likely (ML) code-word. Lin, Shu and Fossorier, Marc Goddard Space Flight Center NAG5-931; NAG5-2938...

*Trellises and Trellis-Based Decoding Algorithms for Linear Block Codes. Part 3; An Iterative Decoding Algorithm for Linear Block Codes Based on a Low-Weight Trellis Search*

"In this work, we introduce a network linear block coding framework for multi-way relaying with differential MPSK modulation. We consider a system with K user terminals and L relays employing a selective detect-and-forward (DF) relaying protocol. Each relay is associated with a relevant group of terminals. During the first K phases, each terminal broadcasts its own signal to relay nodes and all the other terminals. During the following L phases, each relay forwards a linearly combined signal to all the terminals only if all the symbols from its relevant group were detected successfully. Such a system can be represented as a linear block code in systematic form, where the transmissions over direct links provide the information symbols and the relays form the parity check symbols. Therefore, the decoding at each terminal consists of decoding a (K+L,K) linear block code. We first analyse the theoretical performance of our system with optimal decoding, including pairwise error probability, codeword error probability and bit error rate. It is shown that our system can achieve a diversity order equals to the minimum Hamming distance of the equivalent code when using maximum likelihood decoding. For practical implementation, a sub-optimal decoder based on the log-domain belief propagation algorithm is employed at the terminals. We first present numerical results for short binary and 4-ary codes, and then extend the system to large networks using LDPC codes. Both the theoretical and simulation results demonstrate a significant performance gain of our system over an uncoded scheme. The properties of suitable codes for the proposed system are studied, indicating that high-rate systematic LDPC codes with moderate minimum distance and without small girths are suitable for our system. Furthermore, we derive and apply a hard threshold at the terminals to reduce the performance loss of when the terminals don't know which relay transmits compared to when the terminals know which relay transmits. It is shown that such a hard threshold can improve the performance of our system without adding too much complexity. Finally, realistic relays by thresholding received samples and decision variables are considered. This thesis shows that even with such realistic relays, our system can still outperform the uncoded scheme, at least for the error rates of interest." -- *Quantization Issues for Decoding Linear Block Codes Based on Ordered Statistics*

A code trellis is a graphical representation of a code, block or convolutional, in which every path represents a codeword (or a code sequence for a convolutional code). This representation makes it possible to implement Maximum Likelihood Decoding (MLD) of a code with reduced decoding complexity. The most well known trellis-based MLD algorithm is the Viterbi algorithm. The trellis representation was first introduced and used for convolutional codes [23]. This representation, together with the Viterbi decoding algorithm, has resulted in a wide range of applications of convolutional codes for error control in digital communications over the last two decades. There are two major reasons for this inactive period of research in this area. First, most coding theorists at that time believed that block codes did not have simple trellis structure like convolutional codes and maximum likelihood decoding of linear block codes using the Viterbi algorithm was practically impossible, except for very short block codes. Second, since almost all of the linear block codes are constructed algebraically or based on finite geometries, it was the belief of many coding theorists that algebraic decoding was the only way to decode these codes. These two reasons seriously hindered the development of efficient soft-decision decoding methods for linear block codes and their applications to error control in digital communications. This led to a general belief that block codes are inferior to convolutional codes and hence, that they were not useful. Chapter 2 gives a brief review of linear block codes. The goal is to provide the essential background material for the development of trellis structure and trellis-based decoding algorithms for linear block codes in the later chapters. Chapters 3 through 6 present the fundamental concepts, finite-state machine model, state space formulation, basic structural properties, state labeling, construction procedures, complexity, minimality, and sectionaliza...

*Sequential Decoding of Linear Block Codes*

*Undetected Error Behaviour of Linear Block Codes on Channels with Memory*

Techniques to Improve Iterative Decoding of Linear Block Codes

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A Decoding Algorithm for General Linear Block Codes

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