

# Introduction to Coding Theory

- [3] Correcting and detecting error patterns

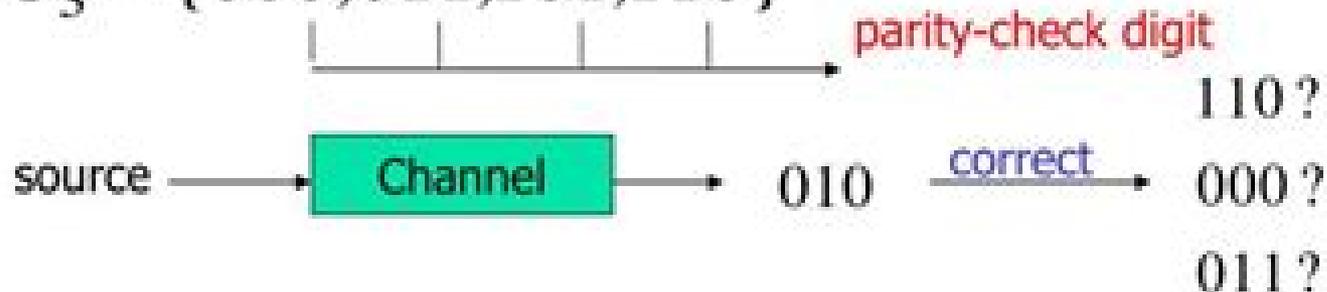
Any received word should be corrected to a codeword that requires as few changes as possible.

$C_1 = \{00, 01, 10, 11\}$  Cannot detect any errors !!!

$C_2 = \{000000, 010101, 101010, 111111\}$



$C_3 = \{000, 011, 101, 110\}$



# Error Correction Coding Theory

**Torleiv Kløve**



## **Error Correction Coding Theory:**

*Error-correcting Codes* William Wesley Peterson, E. J. Weldon, 1972 The coding problem Introduction to algebra Linear codes Error correction capabilities of linear codes Important linear block codes Polynomial rings and Galois fields Linear switching circuits Cyclic codes Bose-Chaudhuri Hocquenghem codes Arithmetic codes     **Error Correcting Codes** Alain Poli, Llorenç Huguet, 1992 This advanced text covers both the theory and applications of coding theory Drawing on recent research the book explains new developments in the field of information coding Included are worked examples and exercises

Error-Correction Coding and Decoding Martin Tomlinson, Cen Jung Tjhai, Marcel A. Ambroze, Mohammed Ahmed, Mubarak Jibril, 2017-02-21 This book discusses both the theory and practical applications of self-correcting data commonly known as error-correcting codes The applications included demonstrate the importance of these codes in a wide range of everyday technologies from smartphones to secure communications and transactions Written in a readily understandable style the book presents the authors' twenty-five years of research organized into five parts Part I is concerned with the theoretical performance attainable by using error-correcting codes to achieve communications efficiency in digital communications systems Part II explores the construction of error-correcting codes and explains the different families of codes and how they are designed Techniques are described for producing the very best codes Part III addresses the analysis of low-density parity check LDPC codes primarily to calculate their stopping sets and low-weight codeword spectrum which determines the performance of these codes Part IV deals with decoders designed to realize optimum performance Part V describes applications which include combined error correction and detection public key cryptography using Goppa codes correcting errors in passwords and watermarking This book is a valuable resource for anyone interested in error-correcting codes and their applications ranging from non-experts to professionals at the forefront of research in their field This book is open access under a CC BY 4.0 license     *Foundations of Coding* Jiri Adamek, 2011-02-14 Although devoted to constructions of good codes for error control secrecy or data compression the emphasis is on the first direction Introduces a number of important classes of error-detecting and error-correcting codes as well as their decoding methods Background material on modern algebra is presented where required The role of error-correcting codes in modern cryptography is treated as are data compression and other topics related to information theory The definition-theorem-proof style used in mathematics texts is employed through the book but formalism is avoided wherever possible     **Error-correcting Coding Theory** Man Young Rhee, 1989     Error Correcting Codes D. J. Baylis, 2018-05-11 Assuming little previous mathematical knowledge *Error Correcting Codes* provides a sound introduction to key areas of the subject Topics have been chosen for their importance and practical significance which Baylis demonstrates in a rigorous but gentle mathematical style Coverage includes optimal codes linear and non-linear codes general techniques of decoding errors and erasures error detection syndrome decoding and much more *Error Correcting Codes* contains not only straight maths but also exercises on more investigational problem solving

Chapters on number theory and polynomial algebra are included to support linear codes and cyclic codes and an extensive reminder of relevant topics in linear algebra is given Exercises are placed within the main body of the text to encourage active participation by the reader with comprehensive solutions provided Error Correcting Codes will appeal to undergraduate students in pure and applied mathematical fields software engineering communications engineering computer science and information technology and to organizations with substantial research and development in those areas

*Error Correcting Coding and Security for Data Networks* Grigorii Kabatiansky, Evgenii Krouk, Sergei Semenov, 2005-10-31 Error correcting coding is often analyzed in terms of its application to the separate levels within the data network in isolation from each other In this fresh approach the authors consider the data network as a superchannel a multi layered entity which allows error correcting coding to be evaluated as it is applied to a number of network layers as a whole By exposing the problems of applying error correcting coding in data networks and by discussing coding theory and its applications this original technique shows how to correct errors in the network through joint coding at different network layers Discusses the problem of reconciling coding applied to different layers using a superchannel approach Includes thorough coverage of all the key codes linear block codes Hamming BCH and Reed Solomon codes LDPC codes decoding as well as convolutional turbo and iterative coding Considers new areas of application of error correcting codes such as transport coding code based cryptosystems and coding for image compression Demonstrates how to use error correcting coding to control such important data characteristics as mean message delay Provides theoretical explanations backed up by numerous real world examples and practical recommendations Features a companion website containing additional research results including new constructions of LDPC codes joint error control coding and synchronization Reed Muller codes and their list decoding By progressing from theory through to practical problem solving this resource contains invaluable advice for researchers postgraduate students engineers and computer scientists interested in data communications and applications of coding theory

**An Introduction to Error Correcting Codes with Applications** Scott A. Vanstone, Paul C. van Oorschot, 2013-04-18 5 2 Rings and Ideals 148 5 3 Ideals and Cyclic Subspaces 152 5 4 Generator Matrices and Parity Check Matrices 159 5 5 Encoding Cyclic Codes 163 5 6 Syndromes and Simple Decoding Procedures 168 5 7 Burst Error Correcting 175 5 8 Finite Fields and Factoring  $x^n - 1$  over  $GF(q)$  181 5 9 Another Method for Factoring  $x^n - 1$  over  $GF(q)$  187 5 10 Exercises 193 Chapter 6 BCH Codes and Bounds for Cyclic Codes 6 1 Introduction 201 6 2 BCH Codes and the BCH Bound 205 6 3 Bounds for Cyclic Codes 210 6 4 Decoding BCH Codes 215 6 5 Linearized Polynomials and Finding Roots of Polynomials 224 6 6 Exercises 231 Chapter 7 Error Correction Techniques and Digital Audio Recording 7 1 Introduction 237 7 2 Reed Solomon Codes 237 7 3 Channel Erasures 240 7 4 BCH Decoding with Erasures 244 7 5 Interleaving 250 7 6 Error Correction and Digital Audio Recording 256 7

**A Course in Error-correcting Codes** Jørn Justesen, Tom Høholdt, 2004 This book is written as a text for a course aimed at advanced undergraduates Chapters cover the codes and decoding

methods that are currently of most interest in research development and application They give a relatively brief presentation of the essential results emphasizing the interrelations between different methods and proofs of all important results A sequence of problems at the end of each chapter serves to review the results and give the student an appreciation of the concepts

**A Short Course on Error Correcting Codes** Neil James Alexander Sloane,1975 *Error Correction Coding* Todd K. Moon,2020-12-22 Providing in depth treatment of error correction Error Correction Coding Mathematical Methods and Algorithms 2nd Edition provides a comprehensive introduction to classical and modern methods of error correction The presentation provides a clear practical introduction to using a lab oriented approach Readers are encouraged to implement the encoding and decoding algorithms with explicit algorithm statements and the mathematics used in error correction balanced with an algorithmic development on how to actually do the encoding and decoding Both block and stream convolutional codes are discussed and the mathematics required to understand them are introduced on a just in time basis as the reader progresses through the book The second edition increases the impact and reach of the book updating it to discuss recent important technological advances New material includes Extensive coverage of LDPC codes including a variety of decoding algorithms A comprehensive introduction to polar codes including systematic encoding decoding and list decoding An introduction to fountain codes Modern applications to systems such as HDTV DVBT2 and cell phones Error Correction Coding includes extensive program files for example C code for all LDPC decoders and polar code decoders laboratory materials for students to implement algorithms and an updated solutions manual all of which are perfect to help the reader understand and retain the content The book covers classical BCH Reed Solomon Golay Reed Muller Hamming and convolutional codes which are still component codes in virtually every modern communication system There are also fulsome discussions of recently developed polar codes and fountain codes that serve to educate the reader on the newest developments in error correction

[Introduction to the Theory of Error-correcting Codes](#) Vera Pless,1982 Introduction to the Theory of Error Correcting Codes Third Edition is the ideal textbook for senior undergraduate and first year graduate courses on error correcting codes in mathematics computer science and electrical engineering *Fundamentals of Error-Correcting Codes* W. Cary Huffman,Vera Pless,2010-02-18 Fundamentals of Error Correcting Codes is an in depth introduction to coding theory from both an engineering and mathematical viewpoint As well as covering classical topics there is much coverage of techniques which could only be found in specialist journals and book publications Numerous exercises and examples and an accessible writing style make this a lucid and effective introduction to coding theory for advanced undergraduate and graduate students researchers and engineers whether approaching the subject from a mathematical engineering or computer science background

*Linear Network Error Correction Coding* Xuan Guang,Zhen Zhang,2014-03-21 There are two main approaches in the theory of network error correction coding In this SpringerBrief the authors summarize some of the most important contributions following the classic approach which represents messages by

sequences similar to algebraic coding and also briefly discuss the main results following the other approach that uses the theory of rank metric codes for network error correction of representing messages by subspaces This book starts by establishing the basic linear network error correction LNEC model and then characterizes two equivalent descriptions Distances and weights are defined in order to characterize the discrepancy of these two vectors and to measure the seriousness of errors Similar to classical error correcting codes the authors also apply the minimum distance decoding principle to LNEC codes at each sink node but use distinct distances For this decoding principle it is shown that the minimum distance of a LNEC code at each sink node can fully characterize its error detecting error correcting and erasure error correcting capabilities with respect to the sink node In addition some important and useful coding bounds in classical coding theory are generalized to linear network error correction coding including the Hamming bound the Gilbert Varshamov bound and the Singleton bound Several constructive algorithms of LNEC codes are presented particularly for LNEC MDS codes along with an analysis of their performance Random linear network error correction coding is feasible for noncoherent networks with errors Its performance is investigated by estimating upper bounds on some failure probabilities by analyzing the information transmission and error correction Finally the basic theory of subspace codes is introduced including the encoding and decoding principle as well as the channel model the bounds on subspace codes code construction and decoding algorithms

**Error Control Coding** Peter Sweeney, 2002-04-29 Error Control Coding From Theory to Practice provides a concise introduction to basic coding techniques and their application The fundamental concepts of coding theory are explained using simple examples with minimum use of complex mathematical tools The selection of appropriate codes and the design of decoders are discussed Bridging the gap between digital communications and information theory this accessible approach will appeal to students and practising engineers alike The clear presentation and practical emphasis make this book an excellent tool for both communications and electronic engineering students Practitioners new to the field will find this text an essential guide to coding Features include End of chapter problems to test and develop the readers understanding of the most popular codes and decoding methods Finite field arithmetic and algebraic decoding methods for BCH and Reed Solomon codes Detailed coverage of Viterbi decoding and related implementation issues Turbo codes and related code types including Gallager codes and turbo product codes Practical examples of MAP and SOVA decoding for turbo codes

**The theory of error-correcting codes** Florence Jessie MacWilliams, Neil James Alexander Sloane, 1977

**Codes for Error Detection** Torleiv Kløve, 2007 There are two basic methods of error control for communication both involving coding of the messages With forward error correction the codes are used to detect and correct errors In a repeat request system the codes are used to detect errors and if there are errors request a retransmission Error detection is usually much simpler to implement than error correction and is widely used However it is given a very cursory treatment in almost all textbooks on coding theory Only a few older books are devoted to error detecting codes This book begins with a short

introduction to the theory of block codes with emphasis on the parts important for error detection The weight distribution is particularly important for this application and is treated in more detail than in most books on error correction A detailed account of the known results on the probability of undetected error on the  $q$  ary symmetric channel is also given

**List**

**Decoding of Error-Correcting Codes** Venkatesan Guruswami, 2004-11-29 How can one exchange information effectively when the medium of communication introduces errors This question has been investigated extensively starting with the seminal works of Shannon 1948 and Hamming 1950 and has led to the rich theory of error correcting codes This theory has traditionally gone hand in hand with the algorithmic theory of decoding that tackles the problem of recovering from the errors efficiently This thesis presents some spectacular new results in the area of decoding algorithms for error correcting codes Specifically it shows how the notion of list decoding can be applied to recover from far more errors for a wide variety of error correcting codes than achievable before A brief bit of background error correcting codes are combinatorial structures that show how to represent or encode information so that it is resilient to a moderate number of errors Specifically an error correcting code takes a short binary string called the message and shows how to transform it into a longer binary string called the codeword so that if a small number of bits of the codeword are flipped the resulting string does not look like any other codeword The maximum number of errors that the code is guaranteed to detect denoted  $d$  is a central parameter in its design A basic property of such a code is that if the number of errors that occur is known to be smaller than  $d/2$  the message is determined uniquely This poses a computational problem called the decoding problem compute the message from a corrupted codeword when the number of errors is less than  $d/2$

**The Theory of Error-Correcting Codes** Florence Jessie MacWilliams, F.J. MacWilliams, N.J.A. Sloane, 1978

**A Short Course on Error Correcting Codes** N.J.A. Sloane, 2014-05-04

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