Error-correcting codes

- Notation: $\mathbb{F}_q$ - finite field of cardinality q
- Encoding function: messages $\mapsto$ codewords
  - $E: \mathbb{F}_q^k \to \mathbb{F}_q^n$; associated Code $C \triangleq \{E(m) | m \in \mathbb{F}_q^k\}$
  - Key parameters:
    - Rate $R(C) = k/n$;
    - Distance $\delta(C) = \min_{x \neq y \in C} \{\delta(x, y)\}$.
      - $\delta(x, y) = \frac{|\{i | x_i \neq y_i\}|}{n}$

- Pigeonhole Principle $\Rightarrow R(C) + \delta(C) \leq 1 + \frac{1}{n}$
- Algebraic codes: Get very close to this limit!

Error Correcting Codes And Finite Fields

Simeon Ball

Error Correcting Codes And Finite Fields:

　　Error-correcting Codes and Finite Fields Oliver Pretzel,2023 Starting with the elementary ideas of parity check codes this work takes the reader via BCH and Reed Solomon codes all the way to the geometric Goppa codes The necessary mathematics is developed in parallel with the applications **Error-correcting Codes and Finite Fields** Oliver Pretzel,1992 Starting with the elementary ideas of parity check codes this work takes the reader via BCH and Reed Solomon codes all the way to the geometric Goppa codes The necessary mathematics is developed in parallel with the applications

　　The Theory of Error-correcting Codes Florence Jessie MacWilliams,Neil James Alexander Sloane,1977 **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 Course in Algebraic Error-Correcting Codes** Simeon Ball,2020-05-08 This textbook provides a rigorous mathematical perspective on error correcting codes starting with the basics and progressing through to the state of the art Algebraic combinatorial and geometric approaches to coding theory are adopted with the aim of highlighting how coding can have an important real world impact Because it carefully balances both theory and applications this book will be an indispensable resource for readers seeking a timely treatment of error correcting codes Early chapters cover fundamental concepts introducing Shannon s theorem asymptotically good codes and linear codes The book then goes on to cover other types of codes including chapters on cyclic codes maximum distance separable codes LDPC codes p adic codes amongst others Those undertaking independent study will appreciate the helpful exercises with selected solutions A Course in Algebraic Error Correcting Codes suits an interdisciplinary audience at the Masters level including students of mathematics engineering physics and computer science Advanced undergraduates will find this a useful resource as well An understanding of linear algebra is assumed **Application of Fourier Transform Over Finite Fields to Error-correcting Codes** David Mun-Hein Choy,1976 *Introduction to the Theory of Error-Correcting Codes* Vera Pless,2011-10-24 A complete introduction to the many mathematical tools used to solve practical problems in coding Mathematicians have been fascinated with the theory of error correcting codes since the publication of Shannon s classic papers fifty years ago With the proliferation of communications systems computers and digital audio devices that employ error correcting codes the theory has taken on practical importance in the solution of coding problems This solution process requires the use of a wide variety of mathematical tools and an understanding of how to find mathematical techniques to solve applied problems Introduction to the Theory of Error Correcting Codes Third Edition demonstrates this process and prepares students to cope with coding problems Like its predecessor which was

awarded a three star rating by the Mathematical Association of America this updated and expanded edition gives readers a firm grasp of the timeless fundamentals of coding as well as the latest theoretical advances This new edition features A greater emphasis on nonlinear binary codes An exciting new discussion on the relationship between codes and combinatorial games Updated and expanded sections on the Vashamov Gilbert bound van Lint Wilson bound BCH codes and Reed Muller codes Expanded and updated problem sets 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 **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 Codest 163 5 6 Syndromes and Simple Decoding Procedures 168 5 7 Burst Error Correcting 175 5 8 Finite Fields and Factoring xn l over GF q 181 5 9 Another Method for Factoring xn l over GF q t 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 Codest 210 6 4 Decoding BCH Codes 215 6 5 Linearized Polynomials and Finding Roots of Polynomialst 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 **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 **VLSI Architectures for Modern Error-Correcting Codes** Xinmiao Zhang,2017-12-19 Error correcting codes are ubiquitous They are adopted in almost every modern digital communication and storage system such as wireless communications optical communications Flash memories computer hard drives sensor networks and deep space probing New generation and emerging applications demand codes with better error correcting capability On the other hand the design and implementation of those high gain error correcting codes pose many challenges They usually involve complex mathematical computations and mapping them directly to hardware often leads to very high complexity VLSI Architectures for Modern Error Correcting Codes serves as a bridge connecting advancements in coding theory to practical hardware implementations Instead of focusing on circuit level design techniques the book highlights integrated algorithmic and architectural transformations that lead to great improvements on throughput silicon area requirement and or power consumption in the hardware implementation The goal of this book is to provide a comprehensive and systematic review of

available techniques and architectures so that they can be easily followed by system and hardware designers to develop en decoder implementations that meet error correcting performance and cost requirements This book can be also used as a reference for graduate level courses on VLSI design and error correcting coding Particular emphases are placed on hard and soft decision Reed Solomon RS and Bose Chaudhuri Hocquenghem BCH codes and binary and non binary low density parity check LDPC codes These codes are among the best candidates for modern and emerging applications due to their good error correcting performance and lower implementation complexity compared to other codes To help explain the computations and en decoder architectures many examples and case studies are included More importantly discussions are provided on the advantages and drawbacks of different implementation approaches and architectures   <u>Application of Fourier Transform Over Finite Fields to Error-correcting Codes</u> David Mun-Hien Choy,1974 BCH code is one of the most powerful and the most extensively studied classes of algebraic error correcting codes Unfortunately it was found that its performance in error correction deteriorates as its length increases In this report a class of algebraic linear codes is proposed based on the structure of Fourier Transform over finite fields This class of codes includes the BCH codes and Srivastava codes as proper subclasses Several constructive bounds on the minimum distance of these codes are derived and are shown to be achievable using Berlekamp s iterative decoding algorithm or using Goppa s method based on divided difference A new distance bound is also obtained for a group of binary Srivastava codes Modified author abstract   <u>Applied Algebra, Algebraic Algorithms and Error-Correcting Codes</u> Serdar Boztas,Igor E. Shparlinski,2001-11-12 The AAECC Symposia Series was started in 1983 by Alain Poli Toulouse who together with R Desq D Lazard and P Camion organized the rst conference Originally the acronym AAECC meant Applied Algebra and Error Correcting Codes Over the years its meaning has shifted to Applied Algebra Algebraic Algorithms and Error Correcting Codes re ecting the growing importance of complexity in both decoding algorithms and computational algebra AAECC aims to encourage cross fertilization between algebraic methods and their applications in computing and communications The algebraic orientation is towards nite elds complexity polynomials and graphs The applications orientation is towards both theoretical and practical error correction coding and since AAECC 13 Hawaii 1999 towards cryptography AAECC was the rst symposium with papers connecting Gr obner bases with E C codes The balance between theoretical and practical is intended to shift regularly at AAECC 14 the focus was on the theoretical side The main subjects covered were Codes iterative decoding decoding methods block codes code construction Codes and algebra algebraic curves Gr obner bases and AG codes Algebra rings and elds polynomials Codes and combinatorics graphs and matrices designs arithmetic Cryptography Computational algebra algebraic algorithms Sequences for communications

Applied Algebra, Algebraic Algorithms, and Error-correcting Codes Teo Mora,1989-05-23 In 1988 for the first time the two international conferences AAECC 6 and ISSAC 88 International Symposium on Symbolic and Algebraic Computation see Lecture Notes in Computer Science 358 have taken place as a Joint Conference in Rome July 4 8 1988 The topics of the

two conferences are in fact widely related to each other and the Joint Conference presented a good occasion for the two research communities to meet and share scientific experiences and results The proceedings of the AAECC 6 are included in this volume The main topics are Applied Algebra Theory and Application of Error Correcting Codes Cryptography Complexity Algebra Based Methods and Applications in Symbolic Computing and Computer Algebra and Algebraic Methods and Applications for Advanced Information Processing Twelve invited papers on subjects of common interest for the two conferences are divided between this volume and the succeeding Lecture Notes volume devoted to ISSACC 88 The proceedings of the 5th conference are published as Vol 356 of the Lecture Notes in Computer Science **Algebraic Coding Theory (Revised Edition)** Elwyn R Berlekamp,2015-03-26 This is the revised edition of Berlekamp s famous book Algebraic Coding Theory originally published in 1968 wherein he introduced several algorithms which have subsequently dominated engineering practice in this field One of these is an algorithm for decoding Reed Solomon and Bose Chaudhuri Hocquenghem codes that subsequently became known as the Berlekamp Massey Algorithm Another is the Berlekamp algorithm for factoring polynomials over finite fields whose later extensions and embellishments became widely used in symbolic manipulation systems Other novel algorithms improved the basic methods for doing various arithmetic operations in finite fields of characteristic two Other major research contributions in this book included a new class of Lee metric codes and precise asymptotic results on the number of information symbols in long binary BCH codes Selected chapters of the book became a standard graduate textbook Both practicing engineers and scholars will find this book to be of great value

Fundamentals of Classical and Modern Error-Correcting Codes Shu Lin,Juane Li,2021-12-09 Using easy to follow mathematics this textbook provides comprehensive coverage of block codes and techniques for reliable communications and data storage It covers major code designs and constructions from geometric algebraic and graph theoretic points of view decoding algorithms error control additive white Gaussian noise AWGN and erasure and dataless recovery It simplifies a highly mathematical subject to a level that can be understood and applied with a minimum background in mathematics provides step by step explanation of all covered topics both fundamental and advanced and includes plenty of practical illustrative examples to assist understanding Numerous homework problems are included to strengthen student comprehension of new and abstract concepts and a solutions manual is available online for instructors Modern developments including polar codes are also covered An essential textbook for senior undergraduates and graduates taking introductory coding courses students taking advanced full year graduate coding courses and professionals working on coding for communications and data storage **Polynomial Methods in Combinatorics** Larry Guth,2016-06-10 This book explains some recent applications of the theory of polynomials and algebraic geometry to combinatorics and other areas of mathematics One of the first results in this story is a short elegant solution of the Kakeya problem for finite fields which was considered a deep and difficult problem in combinatorial geometry The author also discusses in detail various problems in

incidence geometry associated to Paul Erd s s famous distinct distances problem in the plane from the 1940s The proof techniques are also connected to error correcting codes Fourier analysis number theory and differential geometry Although the mathematics discussed in the book is deep and far reaching it should be accessible to first and second year graduate students and advanced undergraduates The book contains approximately 100 exercises that further the reader s understanding of the main themes of the book   *Using Algebraic Geometry* David A. Cox,John Little,Donal O'Shea,2005-11-23 In recent years the discovery of new algorithms for dealing with polynomial equations coupled with their implementation on fast inexpensive computers has sparked a minor revolution in the study and practice of algebraic geometry These algorithmic methods have also given rise to some exciting new applications of algebraic geometry This book illustrates the many uses of algebraic geometry highlighting some of the more recent applications of Gr bner bases and resultants In order to do this the authors provide an introduction to some algebraic objects and techniques which are more advanced than one typically encounters in a first course but nonetheless of great utility The book is written for nonspecialists and for readers with a diverse range of backgrounds It assumes knowledge of the material covered in a standard undergraduate course in abstract algebra and it would help to have some previous exposure to Gr bner bases The book does not assume the reader is familiar with more advanced concepts such as modules For this new edition the authors added two new sections and a new chapter updated the references and made numerous minor improvements throughout the text

Fundamentals of Classical and Modern Error-Correcting Codes Shu Lin,Juane Li,2021-12-09 An accessible textbook that uses step by step explanations relatively easy mathematics and numerous examples to aid student understanding

Combinatorics, Graph Theory and Computing Frederick Hoffman,Sarah Holliday,Zvi Rosen,Farhad Shahrokhi,John Wierman,2024-06-15 This proceedings volume convenes selected revised papers presented at the 52nd Southeastern International Conference on Combinatorics Graph Theory and Computing SEICCGTC 2021 virtually held at Florida Atlantic University in Boca Raton USA on March 8 12 2021 As has been a tradition since its inception in 1970 this edition once more brought together mathematicians practitioners and scientists around novel findings in combinatorics graph theory and computing and their interactions The lectures and works presented at the Conference have proven to be of great interest to other scientists and analysts employing these mathematical sciences in their professional activities in business industry and government Such an environment promotes a better understanding of the roles of modern applied mathematics combinatorics and computer science Many works have demonstrated that disciplines have increasingly contributed to each other With this series of Conferences the gaps between the fields tend to decrease even further This volume is of particular interest for the community of pure and applied mathematicians in academia industry and government working in combinatorics and graph theory as well as related areas of computer science and the interactions among these fields Its findings can also benefit a general audience of practitioners and students from related fields   **Information Theory and**

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