A Review of Polynomial Representations and Arithmetic in Computer Algebra Systems

Richard Fateman

University of California

Berkeley

Polynomial Algorithms In Computer Algebra

Vladimir P. Gerdt,Wolfram Koepf,Ernst W. Mayr,Evgenii V. Vorozhtsov

Polynomial Algorithms In Computer Algebra:

   Polynomial Algorithms in Computer Algebra Franz Winkler,2012-12-06 For several years now I have been teaching courses in computer algebra at the Universitat Linz the University of Delaware and the Universidad de Alcala de Henares In the summers of 1990 and 1992 I have organized and taught summer schools in computer algebra at the Universitat Linz Gradually a set of course notes has emerged from these activities People have asked me for copies of the course notes and different versions of them have been circulating for a few years Finally I decided that I should really take the time to write the material up in a coherent way and make a book out of it Here now is the result of this work Over the years many students have been helpful in improving the quality of the notes and also several colleagues at Linz and elsewhere have contributed to it I want to thank them all for their effort in particular I want to thank B Buchberger who taught me the theory of Grabner bases nearly two decades ago B F Caviness and B D Saunders who first stimulated my interest in various problems in computer algebra G E Collins who showed me how to compute in algebraic domains and J R Sendra with whom I started to apply computer algebra methods to problems in algebraic geometry Several colleagues have suggested improvements in earlier versions of this book However I want to make it clear that I am responsible for all remaining mistakes *Algorithms for Computer Algebra* Keith O. Geddes,Stephen R. Czapor,George Labahn,1992-09-30 Algorithms for Computer Algebra is the first comprehensive textbook to be published on the topic of computational symbolic mathematics The book first develops the foundational material from modern algebra that is required for subsequent topics It then presents a thorough development of modern computational algorithms for such problems as multivariate polynomial arithmetic and greatest common divisor calculations factorization of multivariate polynomials symbolic solution of linear and polynomial systems of equations and analytic integration of elementary functions Numerous examples are integrated into the text as an aid to understanding the mathematical development The algorithms developed for each topic are presented in a Pascal like computer language An extensive set of exercises is presented at the end of each chapter Algorithms for Computer Algebra is suitable for use as a textbook for a course on algebraic algorithms at the third year fourth year or graduate level Although the mathematical development uses concepts from modern algebra the book is self contained in the sense that a one term undergraduate course introducing students to rings and fields is the only prerequisite assumed The book also serves well as a supplementary textbook for a traditional modern algebra course by presenting concrete applications to motivate the understanding of the theory of rings and fields **Computer Algebra and Polynomials** Jaime Gutierrez,Josef Schicho,Martin Weimann,2015-01-20 Algebra and number theory have always been counted among the most beautiful mathematical areas with deep proofs and elegant results However for a long time they were not considered that important in view of the lack of real life applications This has dramatically changed nowadays we find applications of algebra and number theory frequently in our daily life This book focuses on the theory and algorithms for polynomials over various coefficient

domains such as a finite field or ring The operations on polynomials in the focus are factorization composition and decomposition basis computation for modules etc Algorithms for such operations on polynomials have always been a central interest in computer algebra as it combines formal the variables and algebraic or numeric the coefficients aspects The papers presented were selected from the Workshop on Computer Algebra and Polynomials which was held in Linz at the Johann Radon Institute for Computational and Applied Mathematics RICAM during November 25 29 2013 at the occasion of the Special Semester on Applications of Algebra and Number Theory   **Computer Algebra** R. Albrecht,B. Buchberger,G.E. Collins,R. Loos,2013-06-29 The journal Computing has established a series of supplement volumes the fourth of which appears this year Its purpose is to provide a coherent presentation of a new topic in a single volume The previous subjects were Computer Arithmetic 1977 Fundamentals of Numerical Computation 1980 and Parallel Processes and Related Automata 1981 the topic of this 1982 Supplementum to Computing is Computer Algebra This subject which emerged in the early nineteen sixties has also been referred to as symbolic and algebraic computation or formula manipulation Algebraic algorithms have been receiving increasing interest as a result of the recognition of the central role of algorithms in computer science They can be easily specified in a formal and rigorous way and provide solutions to problems known and studied for a long time Whereas traditional algebra is concerned with constructive methods computer algebra is furthermore interested in efficiency in implementation and in hardware and software aspects of the algorithms It develops that in deciding effectiveness and determining efficiency of algebraic methods many other tools recursion theory logic analysis and combinatorics for example are necessary In the beginning of the use of computers for symbolic algebra it soon became apparent that the straightforward textbook methods were often very inefficient Instead of turning to numerical approximation methods computer algebra studies systematically the sources of the inefficiency and searches for alternative algebraic methods to improve or even replace the algorithms   Some Tapas of Computer Algebra Arjeh M. Cohen,Hans Cuypers,Hans Sterk,2013-03-09 In the years 1994 1995 two EIDMA mini courses on Computer Algebra were given at the Eindhoven University of Technology by apart from ourselves various invited lecturers EIDMA is the Research School Euler Institute for Discrete Mathematics and its Applications The idea of the courses was to acquaint young mathematicians with algorithms and software for mathemat ical research and to enable them to incorporate algorithms in their research A collection of lecture notes was used at these courses When discussing these courses in comparison with other kinds of courses one might give in a week s time Joachim Neub ser referred to our courses as tapas This denomination underlined that the courses consisted of appe tizers for various parts of algorithmic algebra indeed we covered such spicy topics as the link between Gr bner bases and integer programming and the detection of algebraic solutions to differential equations As a collection the not es turned out to have some appeal of their own which is the main reason why the idea came up of transforming them into book form We feIt however that the book should be distinguishable from a standard text book on

computer algebra in that it retains its appetizing flavour by presenting a variety of topics at an accessible level with a view to recent developments **Computer Algebra and Symbolic Computation** Joel S. Cohen,2002-07-19 This book provides a systematic approach for the algorithmic formulation and implementation of mathematical operations in computer algebra programming languages The viewpoint is that mathematical expressions represented by expression trees are the data objects of computer algebra programs and by using a few primitive operations that analyze and **Computer Algebra and Symbolic Computation** Joel S. Cohen,2003-01-03 Mathematica Maple and similar software packages provide programs that carry out sophisticated mathematical operations Applying the ideas introduced in Computer Algebra and Symbolic Computation Elementary Algorithms this book explores the application of algorithms to such methods as automatic simplification polynomial decomposition and polyno *Effective Polynomial Computation* Richard Zippel,2012-12-06 Effective Polynomial Computation is an introduction to the algorithms of computer algebra It discusses the basic algorithms for manipulating polynomials including factoring polynomials These algorithms are discussed from both a theoretical and practical perspective Those cases where theoretically optimal algorithms are inappropriate are discussed and the practical alternatives are explained Effective Polynomial Computation provides much of the mathematical motivation of the algorithms discussed to help the reader appreciate the mathematical mechanisms underlying the algorithms and so that the algorithms will not appear to be constructed out of whole cloth Preparatory to the discussion of algorithms for polynomials the first third of this book discusses related issues in elementary number theory These results are either used in later algorithms e g the discussion of lattices and Diophantine approximation or analogs of the number theoretic algorithms are used for polynomial problems e g Euclidean algorithm and p adic numbers Among the unique features of Effective Polynomial Computation is the detailed material on greatest common divisor and factoring algorithms for sparse multivariate polynomials In addition both deterministic and probabilistic algorithms for irreducibility testing of polynomials are discussed *Ideals, Varieties, and Algorithms* David A. Cox,John Little,Donal O'Shea,2025-08-23 This text covers topics in algebraic geometry and commutative algebra with careful attention to their practical and computational aspects The first four chapters form the core of the book A comprehensive chart in the Preface illustrates a variety of ways to proceed with the material once these chapters are covered In addition to the fundamentals of algebraic geometry the elimination theorem the extension theorem the closure theorem and the Nullstellensatz there are chapters on polynomial and rational functions between varieties robotics and geometric theorem proving invariant theory of finite groups projective algebraic geometry dimension theory and progress made over the last decades in computing Gr bner bases The fifth edition builds on the fourth edition in two main ways First a number of typographical errors found by readers and by the authors since 2018 have been corrected Second new material on toric varieties monomial curves and other topics of current interest in algebraic geometry has been added This enhances the opportunities for active learning through new examples new exercises and new projects in Appendix D all supplemented by

additional references The book also includes updated computer algebra material in Appendix C The book may be used for a first or second course in undergraduate abstract algebra and with some augmentation perhaps for beginning graduate courses in algebraic geometry or computational commutative algebra Prerequisites for the reader include linear algebra and a proof oriented course It is assumed that the reader has access to a computer algebra system Appendix C describes features of Maple Mathematica and SageMath as well as other systems that are most relevant to the text Pseudocode is used in the text Appendix B carefully describes the pseudocode used From the reviews of previous editions The book gives an introduction to Buchberger s algorithm with applications to syzygies Hilbert polynomials primary decompositions There is an introduction to classical algebraic geometry with applications to the ideal membership problem solving polynomial equations and elimination theory The book is well written The reviewer is sure that it will be an excellent guide to introduce further undergraduates in the algorithmic aspect of commutative algebra and algebraic geometry Peter Schenzel zbMATH 2007 I consider the book to be wonderful The exposition is very clear there are many helpful pictures and there are a great many instructive exercises some quite challenging offers the heart and soul of modern commutative and algebraic geometry The American Mathematical Monthly **Computing in Algebraic Geometry** Wolfram Decker,Christoph Lossen,2006-05-01 This book provides a quick access to computational tools for algebraic geometry the mathematical discipline which handles solution sets of polynomial equations Originating from a number of intense one week schools taught by the authors the text is designed so as to provide a step by step introduction which enables the reader to get started with his own computational experiments right away The authors present the basic concepts and ideas in a compact way *Mathematics for Computer Algebra* Maurice Mignotte,2012-12-06 This book corresponds to a mathematical course given in 1986 87 at the University Louis Pasteur Strasbourg This work is primarily intended for graduate students The following are necessary prerequisites a few standard definitions in set theory the definition of rational integers some elementary facts in Combinatorics maybe only Newton s binomial formula some theorems of Analysis at the level of high schools and some elementary Algebra basic results about groups rings fields and linear algebra An important place is given to exercises These exercises are only rarely direct applications of the course More often they constitute complements to the text Mostly hints or references are given so that the reader should be able to find solutions Chapters one and two deal with elementary results of Number Theory for example the euclidean algorithm the Chinese remainder theorem and Fermat s little theorem These results are useful by themselves but they also constitute a concrete introduction to some notions in abstract algebra for example euclidean rings principal rings Algorithms are given for arithmetical operations with long integers The rest of the book chapters 3 through 7 deals with polynomials We give general results on polynomials over arbitrary rings Then polynomials with complex coefficients are studied in chapter 4 including many estimates on the complex roots of polynomials Some of these estimates are very useful in the subsequent chapters **Solving Polynomial Equations** Alicia Dickenstein,2005-04-27 This book provides a general

introduction to modern mathematical aspects in computing with multivariate polynomials and in solving algebraic systems It presents the state of the art in several symbolic numeric and symbolic numeric techniques including effective and algorithmic methods in algebraic geometry and computational algebra complexity issues and applications ranging from statistics and geometric modelling to robotics and vision Graduate students as well as researchers in related areas will find an excellent introduction to currently interesting topics These cover Groebner and border bases multivariate resultants residues primary decomposition multivariate polynomial factorization homotopy continuation complexity issues and their applications   *Algorithms for Computer Algebra* K. O. Geddes,1992   Elimination Methods in Polynomial Computer Algebra Valeriĭ Ivanovich Bykov,A. M. Kytmanov,Mark Zakharovich Lazman,Mikael Passare,1998 This book presents a modified method based on multidimensionalresidue theory for the elimination of unknowns from a system ofnonlinear algebraic equations An algorithm is given for constructingthe resultant of the system and a computer implementation making useof formula manipulation software is carried out Programmes in MAPLEare available The algorithms and programmes are then applied toquestions from the theory of chemical kinetics such as the search forall stationary solutions of kinetic equations and the construction ofkinetic polynomials The subject of this book is closely connectedwith a wide range of current problems in the analysis of nonlinearsystems Audience This volume will be of interest to graduate studentsand researchers whose work involves multidimensional theory ofresidues mathematical kinetics computer algebra and symboliccomputation   *Algorithmic Algebra* Bhubaneswar Mishra,2012-12-06 Algorithmic Algebra studies some of the main algorithmic tools of computer algebra covering such topics as Gr bner bases characteristic sets resultants and semialgebraic sets The main purpose of the book is to acquaint advanced undergraduate and graduate students in computer science engineering and mathematics with the algorithmic ideas in computer algebra so that they could do research in computational algebra or understand the algorithms underlying many popular symbolic computational systems Mathematica Maple or Axiom for instance Also researchers in robotics solid modeling computational geometry and automated theorem proving community may find it useful as symbolic algebraic techniques have begun to play an important role in these areas The book while being self contained is written at an advanced level and deals with the subject at an appropriate depth The book is accessible to computer science students with no previous algebraic training Some mathematical readers on the other hand may find it interesting to see how algorithmic constructions have been used to provide fresh proofs for some classical theorems The book also contains a large number of exercises with solutions to selected exercises thus making it ideal as a textbook or for self study   *Computer Algebra in Scientific Computing* Vladimir P. Gerdt,Wolfram Koepf,Ernst W. Mayr,Evgenii V. Vorozhtsov,2012-08-30 This book constitutes the proceedings of the 14th International Workshop on Computer Algebra in Scientific Computing CASC 2012 held in Maribor Slovenia in September 2012 The 28 full papers presented were carefully reviewed and selected for inclusion in this book One of the main themes of the CASC workshop

series namely polynomial algebra is represented by contributions devoted to new algorithms for computing comprehensive Gr bner and involutive systems parallelization of the Gr bner bases computation the study of quasi stable polynomial ideals new algorithms to compute the Jacobson form of a matrix of Ore polynomials a recursive Leverrier algorithm for inversion of dense matrices whose entries are monic polynomials root isolation of zero dimensional triangular polynomial systems optimal computation of the third power of a long integer investigation of the complexity of solving systems with few independent monomials the study of ill conditioned polynomial systems a method for polynomial root finding via eigen solving and randomization an algorithm for fast dense polynomial multiplication with Java using the new opaque typed method and sparse polynomial powering using heaps **EUROCAL '87** James H. Davenport,James Harold Davenport,1989-08-09 This is the sixth in a series of conference proceedings of international conferences on computer algebra held in Europe All the preceding ones have also been published as Lecture Notes in Computer Science They contain original research material not published elsewhere and a few invited lectures summarising the state of the art Computer algebra is the science of using computers to do algebraic calculations rather than the purely arithmetic calculations which we all know computers can do These calculations may be polynomial like calculations one thread of the conference was devoted to polynomial algorithms or may relate to other areas of mathematics such as integration the solution of differential equations or geometry a second thread was devoted to those topics The calculations can be applied in a wide range of scientific and engineering subjects and in branches of mathematics Physics has benefitted especially from these calculations and the proceedings contain many papers on this and also papers on applications in computer aided design and robotics to name but a few other applications The third thread of the proceedings was devoted to these applications and to the computer algebra systems which perform these calculations *Rational Algebraic Curves* J. Rafael Sendra,Franz Winkler,Sonia Pérez-Diaz,2007-10-19 The central problem considered in this introduction for graduate students is the determination of rational parametrizability of an algebraic curve and in the positive case the computation of a good rational parametrization This amounts to determining the genus of a curve its complete singularity structure computing regular points of the curve in small coordinate fields and constructing linear systems of curves with prescribed intersection multiplicities The book discusses various optimality criteria for rational parametrizations of algebraic curves **Computer Algebra in Scientific Computing** Vladimir P. Gerdt,Wolfram Koepf,Werner M. Seiler,Evgenii V. Vorozhtsov,2014-09-01 This book constitutes the proceedings of the 16th International Workshop on Computer Algebra in Scientific Computing CASC 2014 held in Warsaw Poland in September 2014 The 33 full papers presented were carefully reviewed and selected for inclusion in this book The papers address issues such as Studies in polynomial algebra are represented by contributions devoted to factoring sparse bivariate polynomials using the priority queue the construction of irreducible polynomials by using the Newton index real polynomial root finding by means of matrix and polynomial iterations application of the eigenvalue method with symmetry for solving polynomial systems

arising in the vibration analysis of mechanical structures with symmetry properties application of Gr bner systems for computing the absolute reduction number of polynomial ideals the application of cylindrical algebraic decomposition for solving the quantifier elimination problems certification of approximate roots of overdetermined and singular polynomial systems via the recovery of an exact rational univariate representation from approximate numerical data new parallel algorithms for operations on univariate polynomials multi point evaluation interpolation based on subproduct tree techniques

Elimination Methods in Polynomial Computer Algebra V Bykov,A Kytmanov,M Lazman,1998-10-31

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