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# Real Algebraic Geometry



Springer

# Real Algebraic Geometry

**Claus Scheiderer**



## **Real Algebraic Geometry:**

**Real Algebraic Geometry** Vladimir I. Arnold, 2013-04-15 This book is concerned with one of the most fundamental questions of mathematics the relationship between algebraic formulas and geometric images At one of the first international mathematical congresses in Paris in 1900 Hilbert stated a special case of this question in the form of his 16th problem from his list of 23 problems left over from the nineteenth century as a legacy for the twentieth century In spite of the simplicity and importance of this problem including its numerous applications it remains unsolved to this day although as you will now see many remarkable results have been discovered *Real Algebraic Geometry* Jacek Bochnak, Michel

Coste, Marie-Françoise Roy, 2014-01-15 *Real Algebraic Geometry and Topology* Selman Akbulut, 1995 This book contains the proceedings of the Real Algebraic Geometry Topology Conference held at Michigan State University in December 1993 Presented here are recent results and discussions of new ideas pertaining to such topics as resolution theorems algebraic structures topology of nonsingular real algebraic sets and the distribution of real algebraic sets in projective space **A**

**Course in Real Algebraic Geometry** Claus Scheiderer, 2024-09-12 This textbook is designed for a one year graduate course in real algebraic geometry with a particular focus on positivity and sums of squares of polynomials The first half of the book features a thorough introduction to ordered fields and real closed fields including the Tarski Seidenberg projection theorem and transfer principle Classical results such as Artin's solution to Hilbert's 17th problem and Hilbert's theorems on sums of squares of polynomials are presented in detail Other features include careful introductions to the real spectrum and to the geometry of semialgebraic sets The second part studies Archimedean positivstellensätze in great detail and in various settings together with important applications The techniques and results presented here are fundamental to contemporary approaches to polynomial optimization Important results on sums of squares on projective varieties are covered as well The last part highlights applications to semidefinite programming and polynomial optimization including recent research on semidefinite representation of convex sets Written by a leading expert and based on courses taught for several years the book assumes familiarity with the basics of commutative algebra and algebraic varieties as can be covered in a one semester first course Over 350 exercises of all levels of difficulty are included in the book **Real Algebraic Varieties** Frédéric

Mangolte, 2020-09-21 This book gives a systematic presentation of real algebraic varieties Real algebraic varieties are ubiquitous They are the first objects encountered when learning of coordinates then equations but the systematic study of these objects however elementary they may be is formidable This book is intended for two kinds of audiences it accompanies the reader familiar with algebra and geometry at the masters level in learning the basics of this rich theory as much as it brings to the most advanced reader many fundamental results often missing from the available literature the folklore In particular the introduction of topological methods of the theory to non specialists is one of the original features of the book The first three chapters introduce the basis and classical methods of real and complex algebraic geometry The last three

chapters each focus on one more specific aspect of real algebraic varieties A panorama of classical knowledge is presented as well as major developments of the last twenty years in the topology and geometry of varieties of dimension two and three without forgetting curves the central subject of Hilbert's famous sixteenth problem Various levels of exercises are given and the solutions of many of them are provided at the end of each chapter

*Real Algebraic Geometry* Michel Coste, Louis Mahé, 1992 Ten years after the first Rennes international meeting on real algebraic geometry the second one looked at the developments in the subject during the intervening decade see the 6 survey papers listed below Further contributions from the participants on recent research covered real algebra and geometry topology of real algebraic varieties and 16th Hilbert problem classical algebraic geometry techniques in real algebraic geometry algorithms in real algebraic geometry semialgebraic geometry real analytic geometry

CONTENTS Survey papers M Knebusch Semialgebraic topology in the last ten years R Parimala Algebraic and topological invariants of real algebraic varieties Polotovskii G M On the classification of decomposing plane algebraic curves Scheiderer C Real algebra and its applications to geometry in the last ten years some major developments and results Shustin E L Topology of real plane algebraic curves Silhol R Moduli problems in real algebraic geometry Further contributions by S Akbulut and H King C Andradas and J Ruiz A Borobia L Brcker G W Brumfield A Castilla Z Charzynski and P Skibinski M Coste and M Reguiat A Degtyarev Z Denkowska J P Francoise and F Ronga J M Gamboa and C Ueno D Gondard Cozette I V Itenberg P Jaworski A Korchagin T Krasinski and S Spodzieja K Kurdyka H Lombardi M Marshall and L Walter V F Mazurovskii G Mikhalkin T Mostowski and E Rannou E I Shustin N Vorobjov

**Algorithms in Real Algebraic Geometry** Saugata Basu, Richard Pollack, Marie-Françoise Roy, 2006-07-06 This is the first graduate textbook on the algorithmic aspects of real algebraic geometry The main ideas and techniques presented form a coherent and rich body of knowledge Mathematicians will find relevant information about the algorithmic aspects Researchers in computer science and engineering will find the required mathematical background Being self contained the book is accessible to graduate students and even for invaluable parts of it to undergraduate students This second edition contains several recent results on discriminants of symmetric matrices and other relevant topics

*Positive Polynomials* Alexander Prestel, Charles Delzell, 2013-04-17 Positivity is one of the most basic mathematical concepts In many areas of mathematics like analysis real algebraic geometry functional analysis etc it shows up as positivity of a polynomial on a certain subset of  $\mathbb{R}^n$  which itself is often given by polynomial inequalities The main objective of the book is to give useful characterizations of such polynomials It takes as starting point Hilbert's 17th Problem from 1900 and explains how E Artin's solution of that problem eventually led to the development of real algebra towards the end of the 20th century Beyond basic knowledge in algebra only valuation theory as explained in the appendix is needed Thus the monograph can also serve as the basis for a 2 semester course in real algebra

**Real Algebraic Geometry and Optimization** Thorsten

Theobald, 2024-04-18 This book provides a comprehensive and user friendly exploration of the tremendous recent

developments that reveal the connections between real algebraic geometry and optimization two subjects that were usually taught separately until the beginning of the 21st century Real algebraic geometry studies the solutions of polynomial equations and polynomial inequalities over the real numbers Real algebraic problems arise in many applications including science and engineering computer vision robotics and game theory Optimization is concerned with minimizing or maximizing a given objective function over a feasible set Presenting key ideas from classical and modern concepts in real algebraic geometry this book develops related convex optimization techniques for polynomial optimization The connection to optimization invites a computational view on real algebraic geometry and opens doors to applications Intended as an introduction for students of mathematics or related fields at an advanced undergraduate or graduate level this book serves as a valuable resource for researchers and practitioners Each chapter is complemented by a collection of beneficial exercises notes on references and further reading As a prerequisite only some undergraduate algebra is required

**Real Algebraic Geometry and Ordered Structures** Charles N. Delzell, James J. Madden, 2000 This volume contains 16 carefully refereed articles by participants in the Special Semester and the AMS Special Session on Real Algebraic Geometry and Ordered Structures held at Louisiana State University and Southern University Baton Rouge The 23 contributors to this volume were among the 75 mathematicians from 15 countries who participated in the special semester Topics include the topology of real algebraic curves Hilbert's 16th problem moduli of real algebraic curves effective sums of squares of real forms Hilbert's 17th problem efficient real quantifier elimination subanalytic sets and stratifications semialgebraic singularity theory radial vector fields exponential functions and valuations on nonarchimedean ordered fields valued field extensions partially ordered and lattice ordered rings rings of continuous functions spectra of rings and abstract spaces of higher level orderings and real places This volume provides a good overview of the state of the art in this area in the 1990s It includes both expository and original research papers by top workers in this thriving field The authors and editors strived to make the volume useful to a wide audience including students and researchers interested in real algebraic geometry and ordered structures two subjects that are obviously related but seldom brought together

**Ordered Fields and Real Algebraic Geometry** American Mathematical Society. Meeting, 1982

**Real Algebraic Geometry** Jacek Bochnak, Michel Coste, Marie-Francoise Roy, 1998-08-19 The present volume is a translation revision and updating of our book published in French with the title *Geometrie Algebrique Reelle* Since its publication in 1987 the theory has made advances in several directions There have also been new insights into material already in the French edition Many of these advances and insights have been incorporated in this English version of the book so that it may be viewed as being substantially different from the original We wish to thank Michael Buchner for his careful reading of the text and for his linguistic corrections and stylistic improvements The initial Jb T<sub>E</sub>X file was prepared by Thierry van Effelterre The three authors participate in the European research network Real Algebraic and Analytic Geometry The first author was partially supported by NATO Collaborative Research

Grant 960011 Jacek Bochnak April 1998 Michel Coste Marie Françoise Roy Table of Contents Preface V Introduction 1 1  
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Algorithms in Real Algebraic Geometry Saugata Basu, Richard Pollack, Marie-Françoise Roy, 2003 The algorithmic  
 problems of real algebraic geometry such as real root counting deciding the existence of solutions of systems of polynomial  
 equations and inequalities or deciding whether two points belong in the same connected component of a semi algebraic set  
 occur in many contexts In this first ever graduate textbook on the algorithmic aspects of real algebraic geometry the main  
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 computing Mathematicians already aware of real algebraic geometry will find relevant information about the algorithmic  
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 contained the book is accessible to graduate students and even for invaluable parts of it to undergraduate students **Real**  
**Algebraic Geometry** Michel Coste, Louis Mahe, Marie-Françoise Roy, 1992-11-10 Ten years after the first Rennes  
 international meeting on real algebraic geometry the second one looked at the developments in the subject during the  
 intervening decade see the 6 survey papers listed below Further contributions from the participants on recent research  
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 Mazurovskii G Mikhalkin T Mostowski and E Rannou E I Shustin N Vorobjov Recent Advances in Real Algebraic  
Geometry and Quadratic Forms Bill Jacob, Tsit-Yuen Lam, Robert O. Robson, 1994 The papers collected here present an up to  
 date record of the current research developments in the fields of real algebraic geometry and quadratic forms Articles range  
 from the technical to the expository and there are also indications to new research directions **Emerging Applications of**

**Algebraic Geometry** Mihai Putinar, Seth Sullivant, 2008-12-10 Recent advances in both the theory and implementation of computational algebraic geometry have led to new striking applications to a variety of fields of research The articles in this volume highlight a range of these applications and provide introductory material for topics covered in the IMA workshops on Optimization and Control and Applications in Biology Dynamics and Statistics held during the IMA year on Applications of Algebraic Geometry The articles related to optimization and control focus on burgeoning use of semidefinite programming and moment matrix techniques in computational real algebraic geometry The new direction towards a systematic study of non commutative real algebraic geometry is well represented in the volume Other articles provide an overview of the way computational algebra is useful for analysis of contingency tables reconstruction of phylogenetic trees and in systems biology The contributions collected in this volume are accessible to non experts self contained and informative they quickly move towards cutting edge research in these areas and provide a wealth of open problems for future research      Ordered Fields and Real Algebraic Geometry Special Session on Ordered Fields and Real Algebraic Geometry..., 1982      Topology of Real Algebraic Sets Selman Akbulut, Henry King, 2011-12-14 In the Fall of 1975 we started a joint project with the ultimate goal of topologically classifying real algebraic sets This has been a long happy collaboration c f K2 In 1985 while visiting M S R 1 we organized and presented our classification results up to that point in the M S R 1 preprint series AK14 AK17 Since these results are interdependent and require some prerequisites as well as familiarity with real algebraic geometry we decided to make them self contained by presenting them as a part of a book in real algebraic geometry Even though we have not arrived to our final goal yet we feel that it is time to introduce them in a self contained coherent version and demonstrate their use by giving some applications Chapter I gives the overview of the classification program Chapter II has all the necessary background for the rest of the book which therefore can be used as a course in real algebraic geometry It starts with the elementary properties of real algebraic sets and ends with the recent solution of the Nash Conjecture Chapter III and Chapter IV develop the theory of resolution towers Resolution towers are basic topologically defined objects generalizing the notion of manifold      **Real Algebraic Surfaces** Robert Silhol, 2006-11-14

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