Mechanical Theorem Proving in Geometry

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Abstract
Mechanical theorem proving in geometry plays an important role in the research of automated reasoning. In this paper, we introduce three kinds of computerized methods for geometrical theorem proving: the first is Wu´s method in the international community; the second is elimination point method and the third is lower dimension method.

Key words: geometric theorem, Wu's method, elimination point method, lower dimension method

1. Introduction

Mechanical Proving, that is, mechanization method, is to find a method which can be computed steeply step according to a certain rules. Today we usually refer it as " algorithm". The algorithm is applied in the computer programming, mathematical mechanization, and mathematical theorems, This realizes mathematical theorem to be proved with computer.

Mathematics in ancient China is nearly a kind of mechanic mathematics. Today, the method of Cartesian coordination gives this direction a solid step, and provides a simple and clear method for the proof of geometric theorems mechanization.

The mechanical thought of mathematics in ancient China made a deeply influence in Wu Wen-jun's work about mathematics mechanization. In 1976, academician Wu Wen-jun began to enter the field of mathematics mechanization. Since then , he forwards to the mechanization method which establish theoretical basis for the mechanization of mental work. He proves a large class of elementary geometry problems by computer. It is unprecedented in our country. This is a machine proving method and known as Wu's method throughout the world. It is the first system for mechanic proving method and it can give the proof for nontrivial theorem. He makes the Study of Theorem Proving in Geometry more mature.

In 1992, Academician Zhang Jing-zhong visited the USA to research mathematics mechanization and cooperated with Zhou Xian-qing and Gao Xiaos-han. The elimination point method is one that is based on area method. This brings readable Proof to be realized by computer for the first time. This result is significant for academic and mechanical theorem proving in geometry.

In 1998,Yang Lu created lower dimension method. He obtains the achievement in the mechanic proof of inequalities. The achievement of this method is as good as Wu´s method and elimination point method.It is a great achievement in the field of mechanical theorem proving in geometry by Chinese mathematicians.

Next, we will introduce the three methods respectly.

2. Wu´s method

Wu Wen-jun presents a method which is called Wu's method. It is based on Quaternion of traditional mathematics. This method has been solves a series of actual problems in theoretical physics, computer science and other basic science fields. We can use Wu's method to find a proof for the geometric theorem in computer. We introduce three main steps of this method as follows:

Step 1   Choosing a good coordinate system, free variable and restrict variable.

Let us denote the free variables as $u_1, u_2, \cdots, u_n$, and suppose they have nothing to do with the conditions of geometric problems. Similarly, let us denote the restrict variables

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   Methods and examples in mechanical geometry theorem proving Shang-ching Chou,1986   **Mechanical Theorem Proving in Geometries** Wen-tsün Wu,2012-12-06 There seems to be no doubt that geometry originates from such practical

activ ities as weather observation and terrain survey But there are different manners methods and ways to raise the various experiences to the level of theory so that they finally constitute a science F Engels said The objective of mathematics is the study of space forms and quantitative relations of the real world Dur ing the time of the ancient Greeks there were two different methods dealing with geometry one represented by the Euclid s Elements purely pursued the logical relations among geometric entities excluding completely the quantita tive relations as to establish the axiom system of geometry This method has become a model of deduction methods in mathematics The other represented by the relevant work of Archimedes focused on the study of quantitative re lations of geometric objects as well as their measures such as the ratio of the circumference of a circle to its diameter and the area of a spherical surface and of a parabolic sector Though these approaches vary in style have their own features and reflect different viewpoints in the development of geometry both have made great contributions to the development of mathematics The development of geometry in China was all along concerned with quanti tative relations   Mechanical Geometry Theorem Proving Via Groebner Bases Wu Jinzhao,1996   **Groebner Bases and Mechanical Geometry Theorem Proving** Paul Smith Ache,1991   **Machine Proofs in Geometry** Shang-Ching Chou,Xiao-Shan Gao,Jingzhong Zhang,1994 This book reports recent major advances in automated reasoning in geometry The authors have developed a method and implemented a computer program which for the first time produces short and readable proofs for hundreds of geometry theorems The book begins with chapters introducing the method at an elementary level which are accessible to high school students latter chapters concentrate on the main theme the algorithms and computer implementation of the method This book brings researchers in artificial intelligence computer science and mathematics to a new research frontier of automated geometry reasoning In addition it can be used as a supplementary geometry textbook for students teachers and geometers By presenting a systematic way of proving geometry theorems it makes the learning and teaching of geometry easier and may change the way of geometry education   **Geometric Computation** Falai Chen,Dongming Wang,2004-03-29 This book contains tutorial surveys and original research contributions in geometric computing modeling and reasoning Highlighting the role of algebraic computation it covers surface blending implicitization and parametrization automated deduction with Clifford algebra and in real geometry and exact geometric computation Basic techniques advanced methods and new findings are presented coherently with many examples and illustrations Using this book the reader will easily cross the frontiers of symbolic computation computer aided geometric design and automated reasoning The book is also a valuable reference for people working in other relevant areas such as scientific computing computer graphics and artificial intelligence   **Automated Deduction, Cade-12.** Alan Bundy,1994-06-08 This volume contains the reviewed papers presented at the 12th International Conference on Automated Deduction CADE 12 held at Nancy France in June July 1994 The 67 papers presented were selected from 177 submissions and document many of the most important research results in automated deduction since CADE 11 was held in June 1992

The volume is organized in chapters on heuristics resolution systems induction controlling resolutions ATP problems unification LP applications special purpose provers rewrite rule termination ATP efficiency AC unification higher order theorem proving natural systems problem sets and system descriptions   Automated Practical Reasoning Jochen Pfalzgraf,Dongming Wang,2012-12-06 This book is a collection of selected papers written by researchers qf our RISC institute Research Institute for Symbolic Computation along with the ESPRIT MEDLAR Project Mechanizing Deduction in the Logics of Practical Reason ing Naturally the MEDLAR Project was and is the focal point for our institute whose main objective is the combination of foundational research in the area of symbolic computation and possible applications thereof for high tech industrial projects I am grateful to the director of the MEDLAR project Jim Cunningham for his enthusiasm profound expertise and continuous effort to manage a fruitful cooperation between various European working groups in the area of the project and for giving us the opportunity to be part of this challenging endeavor I also acknowledge and feel indebted to Jochen Pfalzgraf for managing the RISC part of the MEDLAR project and to both him and Dongming Wang for editing this volume and organizing the refereeing process   *Mathematics Mechanization* Wen-tsün Wu,2000   **Clifford Algebras and their Applications in Mathematical Physics** Rafal Ablamowicz,Bertfried Fauser,2012-12-06 The plausible relativistic physical variables describing a spinning charged and massive particle are besides the charge itself its Minkowski four po sition X its relativistic linear four momentum P and also its so called Lorentz four angular momentum E 0 the latter forming four trans lation invariant part of its total angular four momentum M Expressing these variables in terms of Poincare covariant real valued functions defined on an extended relativistic phase space 2 7J means that the mutual Pois son bracket relations among the total angular momentum functions Mab and the linear momentum functions pa have to represent the commutation relations of the Poincare algebra On any such an extended relativistic phase space as shown by Zakrzewski 2 7 the natural Poisson bracket relations 1 1 imply that for the splitting of the total angular momentum into its orbital and its spin part 1 2 one necessarily obtains 1 3 On the other hand it is always possible to shift translate the commuting see 1 1 four position xa by a four vector Xa 1 4 so that the total angular four momentum splits instead into a new orbital and a new Pauli Lubanski spin part 1 5 in such a way that 1 6 However as proved by Zakrzewski 2 7J the so defined new shifted four a position functions X must fulfill the following Poisson bracket relations 1   *Clifford Algebras and their Applications in Mathematical Physics* Rafał Abłamowicz,2000 The first part of a two volume set concerning the field of Clifford geometric algebra this work consists of thematically organized chapters that provide a broad overview of cutting edge topics in mathematical physics and the physical applications of Clifford algebras algebras and their applications in physics Algebraic geometry cohomology non communicative spaces q deformations and the related quantum groups and projective geometry provide the basis for algebraic topics covered Physical applications and extensions of physical theories such as the theory of quaternionic spin a projective theory of hadron transformation laws and electron scattering are also presented showing the

broad applicability of Clifford geometric algebras in solving physical problems Treatment of the structure theory of quantum Clifford algebras the connection to logic group representations and computational techniques including symbolic calculations and theorem proving rounds out the presentation *Algebraic Techniques* Hassan Aït-Kaci,Maurice Nivat,2014-05-10 Resolution of Equations in Algebraic Structures Volume 1 Algebraic Techniques is a collection of papers from the Colloquium on Resolution of Equations in Algebraic Structures held in Texas in May 1987 The papers discuss equations and algebraic structures relevant to symbolic computation and to the foundation of programming One paper discusses the complete lattice of simulation congruences associated with the ground atomic theory of hierarchical specification retrieving as the lattice s maximum element Milner s strong bisimulation for CCS Another paper explains algebraic recognizability of subsets of free T algebras or equational theories and covers discrete structures like those of words terms finite trees and finite graphs One paper proposes a general theory of unification using a category theoretic framework for various substitution systems including classical unification E unification and order sorted unification Another paper shows the universality of algebraic equations in computer science Fixpoint theorems in ordered algebraic structures can be applied in computer science These theorems or their variations include semantics and proof theory logic programming as well as efficient strategies for answering recursive queries in deductive data bases The collection is suitable for programmers mathematicians students and instructors involved in computer science and computer technology Computer Algebra in Scientific Computing Vladimir P. Gerdt,Wolfram Koepf,Ernst W. Mayr,Evgenii V. Vorozhtsov,2013-08-15 This book constitutes the proceedings of the 14th International Workshop on Computer Algebra in Scientific Computing CASC 2013 held in Berlin Germany in September 2013 The 33 full papers presented were carefully reviewed and selected for inclusion in this book The papers address issues such as polynomial algebra the solution of tropical linear systems and tropical polynomial systems the theory of matrices the use of computer algebra for the investigation of various mathematical and applied topics related to ordinary differential equations ODEs applications of symbolic computations for solving partial differential equations PDEs in mathematical physics problems arising at the application of computer algebra methods for finding infinitesimal symmetries applications of symbolic and symbolic numeric algorithms in mechanics and physics automatic differentiation the application of the CAS Mathematica for the simulation of quantum error correction in quantum computing the application of the CAS GAP for the enumeration of Schur rings over the group A5 constructive computation of zero separation bounds for arithmetic expressions the parallel implementation of fast Fourier transforms with the aid of the Spiral library generation system the use of object oriented languages such as Java or Scala for implementation of categories as type classes a survey of industrial applications of approximate computer algebra **Computational Science and Its Applications - ICCSA 2011** Beniamino Murgante,Osvaldo Gervasi,Andres Iglesias,David Taniar,Bernady O. Apduhan,2011-06-17 The five volume set LNCS 6782 6786 constitutes the refereed proceedings of the International Conference on Computational Science and Its Applications

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