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# Algebraic Geodesy and Geoinformatics

2nd Ed.



 Springer

# Algebraic Geodesy And Geoinformatics

**Joseph L. Awange, John B. Kyalo Kiema**



## **Algebraic Geodesy And Geoinformatics:**

**Algebraic Geodesy and Geoinformatics** Joseph L. Awange, Erik W. Grafarend, Béla Paláncz, Pirooska Zaletnyik, 2010-05-27 While preparing and teaching Introduction to Geodesy I and II to undergraduate students at Stuttgart University we noticed a gap which motivated the writing of the present book Almost every topic that we taught required some skills in algebra and in particular computer algebra From positioning to transformation problems inherent in geodesy and geoinformatics knowledge of algebra and application of computer algebra software were required In preparing this book therefore we have attempted to put together basic concepts of abstract algebra which underpin the techniques for solving algebraic problems Algebraic computational algorithms useful for solving problems which require exact solutions to nonlinear systems of equations are presented and tested on various problems Though the present book focuses mainly on the two elds the concepts and techniques presented herein are nonetheless applicable to other elds where algebraic computational problems might be encountered In Engineering for example network densi cation and robotics apply resection and intersection techniques which require algebraic solutions Solution of nonlinear systems of equations is an indispensable task in almost all geosciences such as geodesy geoinformatics geophysics just to mention but a few as well as robotics These equations which require exact solutions underpin the operations of ranging resection intersection and other techniques that are normally used Examples of problems that require exact solutions include three dimensional resection problem for determining positions and orientation of sensors e g camera theodolites robots scanners etc

**Algebraic Geodesy and Geoinformatics** Joseph L. Awange, Erik W. Grafarend, B. La Pal Ncz, 2010-05-29

**Solving Algebraic Computational Problems in Geodesy and Geoinformatics** Joseph L. Awange, Erik W. Grafarend, 2005-08-29 While preparing and teaching Introduction to Geodesy I and II to undergraduate students at Stuttgart University we noticed a gap which motivated the writing of the present book Almost every topic that we taught required some skills in algebra and in particular computer algebra From positioning to transformation problems inherent in geodesy and geoinformatics knowledge of algebra and application of computer algebra software were required In preparing this book therefore we have attempted to put together basic concepts of abstract algebra which underpin the techniques for solving algebraic problems Algebraic computational algorithms useful for solving problems which require exact solutions to nonlinear systems of equations are presented and tested on various problems Though the present book focuses mainly on the two elds the concepts and techniques presented herein are nonetheless applicable to other elds where algebraic computational problems might be encountered In Engineering for example network densi cation and robotics apply resection and intersection techniques which require algebraic solutions Solution of nonlinear systems of equations is an indispensable task in almost all geosciences such as geodesy geoinformatics geophysics just to mention but a few as well as robotics These equations which require exact solutions underpin the operations of ranging resection intersection and other techniques that are normally used Examples of

problems that require exact solutions include three dimensional resection problem for determining positions and orientation of sensors e g camera theodolites robots scanners etc VIII Preface coordinate transformation to match shapes and sizes of points in different systems mapping from topography to reference ellipsoid and analytical determination of refraction angles in GPS meteorology *Geospatial Algebraic Computations* Joseph Awange, Béla Paláncz, 2016-01-29 Improved geospatial instrumentation and technology such as in laser scanning has now resulted in millions of data being collected e g point clouds It is in realization that such huge amount of data requires efficient and robust mathematical solutions that this third edition of the book extends the second edition by introducing three new chapters Robust parameter estimation Multiobjective optimization and Symbolic regression Furthermore the linear homotopy chapter is expanded to include nonlinear homotopy These disciplines are discussed first in the theoretical part of the book before illustrating their geospatial applications in the applications chapters where numerous numerical examples are presented The renewed electronic supplement contains these new theoretical and practical topics with the corresponding Mathematica statements and functions supporting their computations introduced and applied This third edition is renamed in light of these technological advancements *Trends in Geomatics* Rifaat Abdalla, 2019-02-20 The applications of geomatics technology in its broader context have resulted in significant progress in the field of earth science This book provides brief coverage on some trends in geomatics technology as it relates to earth scientists The development in geomatics whether GIS remote sensing GPS or photogrammetry can be seen from trends in the applications of Big Data Smart City Internet of Things IoT the use of augmented reality and utilization of unmanned aerial vehicles UAVs and in the impact of machine learning and AI on geomatics **Environmental Geoinformatics** Joseph L. Awange, John B. Kyalo Kiema, 2013-06-13 There is no doubt that today perhaps more than ever before humanity faces a myriad of complex and demanding challenges These include natural resource depletion and environmental degradation food and water insecurity energy shortages diminishing biodiversity increasing losses from natural disasters and climate change with its associated potentially devastating consequences such as rising sea levels These human induced and natural impacts on the environment need to be well understood in order to develop informed policies decisions and remedial measures to mitigate current and future negative impacts To achieve this continuous monitoring and management of the environment to acquire data that can be soundly and rigorously analyzed to provide information about its current state and changing patterns and thereby allow predictions of possible future impacts are essential Developing pragmatic and sustainable solutions to address these and many other similar challenges requires the use of geodata and the application of geoinformatics This book presents the concepts and applications of geoinformatics a multidisciplinary field that has at its core different technologies that support the acquisition analysis and visualization of geodata for environmental monitoring and management We depart from the 4D to the 5D data paradigm which defines geodata accurately consistently rapidly and completely in order to be useful without any restrictions in space time or scale to represent a truly global

dimension of the digital Earth The book also features the state of the art discussion of Web GIS The concepts and applications of geoinformatics presented in this book will be of benefit to decision makers across a wide range of fields including those at environmental agencies in the emergency services public health and epidemiology crime mapping environmental management agencies tourist industry market analysis and e commerce or mineral exploration among many others The title and subtitle of this textbook convey a distinct message Monitoring the passive part in the subtitle refers to observation and data acquisition whereas management the active component stands for operation and performance The topic is our environment which is intimately related to geoinformatics The overall message is all the mentioned elements do interact and must not be separated Hans Peter Bahr Prof Dr Ing Dr h c Karlsruhe Institute of Technology KIT Germany

**Mathematical Geosciences** Joseph L. Awange, Béla Paláncz, Robert H. Lewis, Lajos Völgyesi, 2018-01-29 This book showcases powerful new hybrid methods that combine numerical and symbolic algorithms Hybrid algorithm research is currently one of the most promising directions in the context of geosciences mathematics and computer mathematics in general One important topic addressed here with a broad range of applications is the solution of multivariate polynomial systems by means of resultants and Groebner bases But that's barely the beginning as the authors proceed to discuss genetic algorithms integer programming symbolic regression parallel computing and many other topics The book is strictly goal oriented focusing on the solution of fundamental problems in the geosciences such as positioning and point cloud problems As such at no point does it discuss purely theoretical mathematics The book delivers hybrid symbolic numeric solutions which are a large and growing area at the boundary of mathematics and computer science Dr Daniel Lichtbau Mathematical Software -- ICMS 2014 Hoon Hong, Chee Yap, 2014-08-01 This book constitutes the proceedings of the 4th International Conference on Mathematical Software ICMS 2014 held in Seoul South Korea in August 2014 The 108 papers included in this volume were carefully reviewed and selected from 150 submissions The papers are organized in topical sections named invited exploration group coding topology algebraic geometry surfaces reasoning special Groebner triangular parametric interfaces and general Environmental Geoinformatics Joseph Awange, John Kiema, 2018-12-08 This second edition includes updated chapters from the first edition as well as five additional new chapters Light detection and ranging LiDAR CORONA historical declassified products Unmanned Aircraft Vehicles UAVs GNSS reflectometry and GNSS applications to climate variability shifting the main focus from monitoring and management to extreme hydro climatic and food security challenges and exploiting big data Since the publication of first edition much has changed in terms of technology and the demand for geospatial data has increased with the advent of the big data era For instance the use of laser scanning has advanced so much that it is unavoidable in most environmental monitoring tasks whereas unmanned aircraft vehicles UAVs drones are emerging as efficient tools that address food security issues as well as many other contemporary challenges Furthermore global navigation satellite systems GNSS are now responding to challenges posed by climate change by

unravelling the impacts of teleconnection e g ENSO as well as advancing the use of reflected signals GNSS reflectometry to monitor e g soil moisture variations Indeed all these rely on the explosive use of big data in many fields of human endeavour Moreover with the ever increasing global population intense pressure is being exerted on the Earth s resources leading to significant changes in its land cover e g deforestation diminishing biodiversity and natural habitats dwindling fresh water supplies and changing weather and climatic patterns e g global warming changing sea level Environmental monitoring techniques that provide information on these are under scrutiny from an increasingly environmentally conscious society that demands the efficient delivery of such information at a minimal cost Environmental changes vary both spatially and temporally thereby putting pressure on traditional methods of data acquisition some of which are highly labour intensive such as animal tracking for conservation purposes With these challenges conventional monitoring techniques particularly those that record spatial changes call for more sophisticated approaches that deliver the necessary information at an affordable cost One direction being pursued in the development of such techniques involves environmental geoinformatics which can act as a stand alone method or complement traditional methods

**Geometric Algebra Computing** Eduardo Bayro-Corrochano, Gerik Scheuermann, 2010-05-19 This useful text offers new insights and solutions for the development of theorems algorithms and advanced methods for real time applications across a range of disciplines Its accessible style is enhanced by examples figures and experimental analysis

**Environmental Project Management** Ebenezer A. Sholarin, Joseph L. Awange, 2016-04-22 This book offers a new framework that facilitates the development of more intelligent systems and methods for data analysis and international information sharing such as the use of satellite imaging and geospatial data to predict changes in weather conditions and shifts in water levels and to assess the extent of the forest cover remaining on Earth that is visible from space It brings together the many aspects of science and technology as well as formula and analytical approaches required for more informed decision making It also highlights the vital importance of understanding the technological economic and social dimensions of environmental projects that have short term results and long term impacts It is unique in that it clearly distinguishes between environmental project management EnvPM and green project management GreenPM and presents an amalgamation of environmental management and project management concepts using geospatial methods to form an EnvPM concept The book sets a benchmark for the professionalism with which environmental projects should be planned executed monitored assessed and delivered While primarily intended for professionals responsible for the management of environmental projects or interested in improving the overall efficiency of such projects it is also a useful handbook for managers in the private public and non for profit sectors It is a valuable resource for students at both undergraduate and master s levels and an indispensable guide for anyone wanting to develop their skills in modern project management environmental management and geospatial techniques We are the first generation to feel the impact of climate change and the last generation that can do something about it US President Obama s address to

the United Nations on Climate Change and Global warming 2015 hison This book provides an in depth well researched and science based approach to applying key project management and spatial tools and practices in environmental projects An important read for leaders considering projects that balance social economic growth against minimising its ill effects on Planet Earth Todd Hutchison Global Chairman of Peopleistic group

**A Window on the Future of Geodesy** Fernando Sansò, 2006-06-09 Every four years the International Association of Geodesy meets at the IUGG General Assembly and this has always been an important event for IAG to make the point on where are we going as geodesists both in terms of scientific production as well as in terms of organization The proceedings of IAG at the Sapporo 2003 General Assembly are the mirror of our scientific achievements and as Geodesy is a living entity like any other science we could say it is a way to see the picture of what we consider our field of applications as well as of theoretical speculations Let us examine this aspect in terms of what are the object of our research the methods we use the general scientific results we can produce Our object here I would like to use a pseudo Helmert definition the object of Geodesy is knowing the surfaces of the earth the geometric surface by positioning and e m surveying and the physical surface i e the gravity field by land marine or satellite gravimetry and their time variations This object is naturally interlaced with other physical properties of the earth both through deep processes affecting its surface and through the gravity field at all different scales from the global to the regional and local where most engineering applications take place

**GNSS Environmental Sensing** Joseph Awange, 2017-09-04 This book is the second edition of Environmental Monitoring using GNSS and highlights the latest developments in global navigation satellite systems GNSS It features a completely new title and additional chapters that present emerging challenges to environmental monitoring climate variability change and food insecurity Since the publication of the first edition much has changed in both the development and applications of GNSS a satellite microwave remote sensing technique It is the first tool to span all four dimensions of relevance to humans position navigation timing and the environment and it has widely been used for positioning both by military and civilians navigation and timing Its increasing use is leading to a new era of remote sensing that is now revolutionizing the art of monitoring our environment in ways never imagined before On the one hand nearly all GNSS satellites Global Positioning System GPS Global Navigation Satellite System GLONASS Galileo and Beidou have become operational thereby providing high precision continuous all weather and near real time remote sensing multi signals beneficial to environmental monitoring On the other hand the emerging challenges of precisely monitoring climate change and the demand for the production of sufficient food for ever increasing populations are pushing traditional monitoring methods to their limits In this regard refracted GNSS signals i e occulted GNSS signals or GNSS meteorology are now emerging as sensors of climate variability while the reflected signals GNSS reflectometry or GNSS R are increasingly finding applications in determining e g soil moisture content ice and snow thickness ocean heights and wind speed and direction among others Furthermore the increasing recognition and application of GNSS supported unmanned aircraft

vehicles UAV drones in agriculture e.g. through the determination of water holding capacity of soil highlights the new challenges facing GNSS. As such, this new edition has three new chapters addressing GNSS reflectometry and applications, GNSS sensing of climate variability and the applications in UAV drones. Moreover, it explores the application of GNSS to support integrated coastal zone management.

**Advanced Procrustes Analysis Models in Photogrammetric Computer Vision** Fabio Crosilla, Alberto Beinat, Andrea Fusiello, Eleonora Maset, Domenico Visintini, 2019-02-28. This book gives a comprehensive view of the developed Procrustes models including the isotropic, the generalized, and the anisotropic variants. These represent original tools to perform, among others, the bundle block adjustment and the global registration of multiple 3D LiDAR point clouds. Moreover, the book also reports the recently derived total least squares solution of the anisotropic Procrustes model together with its practical application in solving the exterior orientation of one image. The book is aimed at all those interested in discovering valuable innovative algorithms for solving various photogrammetric computer vision problems. In this context, where functional models are non-linear, Procrustean methods prove to be powerful since they do not require any linearization nor approximated values of the unknown parameters, furnishing at the same time results comparable in terms of accuracy with those given by the state-of-the-art methods.

**Applications of Linear and Nonlinear Models** Erik Grafarend, Joseph L. Awange, 2012-08-15. Here we present a nearly complete treatment of the Grand Universe of linear and weakly nonlinear regression models within the first 8 chapters. Our point of view is both an algebraic view as well as a stochastic one. For example, there is an equivalent lemma between a best linear unbiased estimation (BLUE) in a Gauss Markov model and a least squares solution (LS) in a system of linear equations. While BLUE is a stochastic regression model, LS is an algebraic solution. In the first six chapters, we concentrate on underdetermined and overdetermined linear systems as well as systems with a datum defect. We review estimators, algebraic solutions of type MINOLESS, BLIMBE, BLUMBE, BLUE, BIQUE, BLE, BIQUE, and Total Least Squares. The highlight is the simultaneous determination of the first moment and the second central moment of a probability distribution in an inhomogeneous multilinear estimation by the so-called E-D correspondence as well as its Bayes design. In addition, we discuss continuous networks versus discrete networks, use of Grassmann-Plücker coordinates, criterion matrices of type Taylor-Karman as well as FUZZY sets. Chapter seven is a speciality in the treatment of an overdetermined system of nonlinear equations on curved manifolds. The von Mises-Fisher distribution is characteristic for circular or hyper-spherical data. Our last chapter, eight, is devoted to probabilistic regression, the special Gauss Markov model with random effects leading to estimators of type BLIP and VIP, including Bayesian estimation. A great part of the work is presented in four Appendices. Appendix A is a treatment of tensor algebra, namely linear algebra, matrix algebra, and multilinear algebra. Appendix B is devoted to sampling distributions and their use in terms of confidence intervals and confidence regions. Appendix C reviews the elementary notions of statistics, namely random events and stochastic processes. Appendix D introduces the basics of Gröbner basis algebra, its careful

definition the Buchberger Algorithm especially the C F Gauss combinatorial algorithm      **Applications of Linear and Nonlinear Models** Erik W. Grafarend, Silvelyn Zwanzig, Joseph L. Awange, 2022-10-01 This book provides numerous examples of linear and nonlinear model applications Here we present a nearly complete treatment of the Grand Universe of linear and weakly nonlinear regression models within the first 8 chapters Our point of view is both an algebraic view and a stochastic one For example there is an equivalent lemma between a best linear uniformly unbiased estimation BLUE in a Gauss Markov model and a least squares solution LESS in a system of linear equations While BLUE is a stochastic regression model LESS is an algebraic solution In the first six chapters we concentrate on underdetermined and overdetermined linear systems as well as systems with a datum defect We review estimators algebraic solutions of type MINOLESS BLIMBE BLUMBE BLUE BIQUE BLE BIQUE and total least squares The highlight is the simultaneous determination of the first moment and the second central moment of a probability distribution in an inhomogeneous multilinear estimation by the so called E D correspondence as well as its Bayes design In addition we discuss continuous networks versus discrete networks use of Grassmann Plucker coordinates criterion matrices of type Taylor Karman as well as FUZZY sets Chapter seven is a speciality in the treatment of an overjet This second edition adds three new chapters 1 Chapter on integer least squares that covers i model for positioning as a mixed integer linear model which includes integer parameters ii The general integer least squares problem is formulated and the optimality of the least squares solution is shown iii The relation to the closest vector problem is considered and the notion of reduced lattice basis is introduced iv The famous LLL algorithm for generating a Lovasz reduced basis is explained 2 Bayes methods that covers i general principle of Bayesian modeling Explain the notion of prior distribution and posterior distribution Choose the pragmatic approach for exploring the advantages of iterative Bayesian calculations and hierarchical modeling ii Present the Bayes methods for linear models with normal distributed errors including noninformative priors conjugate priors normal gamma distributions and iii short outview to modern application of Bayesian modeling Useful in case of nonlinear models or linear models with no normal distribution Monte Carlo MC Markov chain Monte Carlo MCMC approximative Bayesian computation ABC methods 3 Error in variables models which cover i Introduce the error in variables EIV model discuss the difference to least squares estimators LSE ii calculate the total least squares TLS estimator Summarize the properties of TLS iii explain the idea of simulation extrapolation SIMEX estimators iv introduce the symmetrized SIMEX SYMEX estimator and its relation to TLS and v short outview to nonlinear EIV models The chapter on algebraic solution of nonlinear system of equations has also been updated in line with the new emerging field of hybrid numeric symbolic solutions to systems of nonlinear equations ermined system of nonlinear equations on curved manifolds The von Mises Fisher distribution is characteristic for circular or hyper spherical data Our last chapter is devoted to probabilistic regression the special Gauss Markov model with random effects leading to estimators of type BLIP and VIP including Bayesian estimation A great part of the work is presented in four

appendices Appendix A is a treatment of tensor algebra namely linear algebra matrix algebra and multilinear algebra Appendix B is devoted to sampling distributions and their use in terms of confidence intervals and confidence regions Appendix C reviews the elementary notions of statistics namely random events and stochastic processes Appendix D introduces the basics of Groebner basis algebra its careful definition the Buchberger algorithm especially the C F Gauss combinatorial algorithm

**Environmental Monitoring using GNSS** Joseph L. Awange, 2012-05-15 Global Navigation Satellite Systems GNSS are revolutionizing the world in a way their original developers never envisaged From being military war tools GNSS satellites are rapidly becoming peace tools that play a potentially critical role in enabling changing environmental phenomenon that do not permit direct measurements to be remotely observed via their all weather highly accurate and continuously updatable positional time series This is evident for example in their use in emerging environmental monitoring methods that are considered in this book These include GPS based radio telemetry which is enhancing ecological and conservation monitoring by more accurately mapping animal movements their behaviours and their impact on the environment GNSS meteorology which is contributing to weather and climate change studies GNSS remote sensing which for example allows the rapid monitoring of changes in fresh water resources and cryosphere Geosensor network techniques which are earning a crucial role in disaster response management Epidemiology for improved efficiency in tracking and studying the spread of infectious diseases and climate change effects on vector borne diseases and Economics to provide data for the econometric modelling of casual impact of policies In Environmental Impact Assessments EIA Strategic Environmental Assessments SEA and Sustainability Assessments SA GNSS together with other spaced based remote sensing techniques are emerging not only as modern tools that connect the developers to the community but also provide information that support Multi Criteria Analysis MCA methods which inform decision making and policy formulations By bringing the two fields of geodesy the parent of GNSS technology and environmental studies potential users of this technology this book presents the concepts of GNSS in a simplified way that can on the one hand be understood and utilised by environmentalists while on the other outlines its potential applications to environmental monitoring and management for those engaged more with its technology which hopefully will further energise the already innovative research that is being carried out Lastly this book is most relevant to all the professionals whose work is related to the environment such as hydrologists meteorologists epidemiologists economist and engineers to name just a few A comprehensive yet candid and compelling presentation of Global Navigation Satellite Systems and its application to environmental monitoring and a host of other socio economic activities This is an essential and new ground breaking reading for all professional practitioners and even academics seeking to study and become involved in using Global Navigation Satellite Systems in diverse fields ranging from environmental monitoring to economic activities such as monitoring weather and climate in order to design crop failure insurance Nathaniel O Agola Professor of Business and Financial Economics Ritsumeikan University Japan

**Cartography**

Carlos Bateira,2012-08-17 The terrestrial space is the place of interaction of natural and social systems The cartography is an essential tool to understand the complexity of these systems their interaction and evolution This brings the cartography to an important place in the modern world The book presents several contributions at different areas and activities showing the importance of the cartography to the perception and organization of the territory Learning with the past or understanding the present the use of cartography is presented as a way of looking to almost all themes of the knowledge **VII**

**Hotine-Marussi Symposium on Mathematical Geodesy** Nico Sneeuw,Pavel Novák,Mattia Crespi,Fernando

Sansò,2012-02-02 The Hotine Marussi Symposium is the core meeting of a think tank a group of scientists in the geodetic environment working on theoretical and methodological subjects while maintaining the foundations of geodesy to the proper level by corresponding to the strong advancements improved by technological development in the field of ICT electronic computing space technology new measurement devices etc The proceedings of the symposium cover a broad area of arguments which integrate the foundations of geodesy as a science The common feature of the papers therefore is not on the object but rather in the high mathematical standards with which subjects are treated **Moon-Based Synthetic Aperture**

**Radar** Zhen Xu,Kun-Shan Chen,2024-06-04 Lunar explorations have received increasing attention in recent years with tremendous application values including using the Moon as a remote sensing platform for Earth observation As an active sensor the Synthetic Aperture Radar SAR can detect changes in the atmosphere terrain and ocean Moon based SAR complementary to the spaceborne SAR systems expands our capabilities of watching and understanding the Earth This book explains the Moon Earth observation geometry generic parameters image focusing and outlook using the Moon based SAR Written as a SAR imaging of Earth on the lunar based platform it makes it an essential reference to those interested in planetary and Earth sciences **FEATURES** Uses the Moon as a remote sensing platform for Earth observation Explains how to obtain a high spatial resolution with a short revisit time using the Moon based SAR Covers the observation geometry range and signal models two dimensional signal spectrum and focusing algorithms for the Moon based SAR Presents a detailed analysis of sources of phase errors in the Moon based SAR signal Includes global case studies and introduces conceptual ideas for further research This book is intended for senior graduate students professional researchers and engineers studying and working in the fields of lunar exploration and remote sensing applications especially when dealing with high orbit SAR studies

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