

**René Alt  
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LNCSE 2991

# **Numerical Software with Result Verification**

**International Dagstuhl Seminar  
Dagstuhl Castle, Germany, January 2003  
Revised Papers**



**Springer**

# Numerical Software With Result Verification

**Bo Einarsson**



## **Numerical Software With Result Verification:**

**Numerical Software with Result Verification** René Alt, Andreas Frommer, R. Baker Kearfott, Wolfram Luther, 2004-02-12 Reliable computing techniques are essential if the validity of the output of a numerical algorithm is to be guaranteed to be correct Our society relies more and more on computer systems Usually our systems appear to work successfully but there are sometimes serious and often minor errors Validated computing is one essential technology to achieve increased software reliability Formal logic in the definition of data types the computer arithmetic in algorithm design and in program execution allows us to guarantee that the stated problem has or does not have a solution in an enclosing interval we compute If the enclosure is narrow we are certain that the result can be used Otherwise we have a clear warning that the uncertainty of input values might be large and the algorithm and the model have to be improved The use of interval data types and algorithms with controlled rounding and result verification capture uncertainty in modeling and problem formulation in model parameter estimation in algorithm truncation in operation round off and in model interpretation The techniques of validated computing have proven their merits in many scientific and engineering applications They are based on solid and interesting theoretical studies in mathematics and computer science Contributions from fields including real complex and functional analysis semigroups probability statistics fuzzy interval analysis fuzzy logic automatic differentiation computer hardware operating systems compiler construction programming languages object oriented modeling parallel processing and software engineering are all essential

**Numerical Software with Result Verification** René Alt, Andreas Frommer, R. Baker Kearfott, 2014-01-15

**Numerical Software Verification** Alessandro Abate, Sylvie Boldo, 2017-07-11 This book constitutes the proceedings of the 10th International Workshop on Numerical Software Verification NSV 2017 held in Heidelberg Germany in July 2017 colocated with the International Workshop on Formal Methods for Rigorous Systems Engineering of Cyber Physical Systems RISE4CPS 2017 a one time invited only event The 3 full papers presented together with 3 short papers 2 keynote abstracts and 4 invited abstracts were carefully reviewed and selected from numerous submissions The NSV 2017 workshop is dedicated to the development of logical and mathematical techniques for the reasoning about programmability and reliability

Numerical Software Verification Majid Zamani, Damien Zufferey, 2019-08-02 This book constitutes the proceedings of the 12th International Workshop on Numerical Software Verification NSV 2019 held in New York City NY USA in July 2019 colocated with the International Conference on Computer Aided Verification CAV 2019 The 5 full papers presented together with 2 short papers 3 abstracts of invited talks and 2 tutorial papers were carefully reviewed and selected from numerous submissions The NSV 2017 workshop is dedicated to the development of logical and mathematical techniques for the reasoning about programmability and reliability

Numerical Software Verification Sergiy Bogomolov, Matthieu Martel, Pavithra Prabhakar, 2017-02-14 This book constitutes the refereed proceedings of the 9th International Workshop on Numerical Software Verification NSV 2016 held in Toronto ON Canada in

July 2011 colocated with CAV 2016 the 28th International Conference on Computer Aided Verification The NSV workshop is dedicated to the development of logical and mathematical techniques for the reasoning about programmability and reliability

**Quality of Numerical Software** Ronald F. Boisvert, 2016-01-09 Numerical software is central to our computerized society It is used to control aeroplanes and bridges operate manufacturing lines control power plants and refineries and analyse financial markets Such software must be accurate reliable robust efficient easy to use maintainable and adaptable Quality assessment and control of numerical software is still not well understood Although measurement is a key element it remains difficult to assess many components of software quality and to evaluate the trade offs between them Fortunately as numerical software is built upon a long established foundation of mathematical and computational knowledge there is great potential for dramatic breakthroughs This volume will address enabling techniques and tools such as benchmarks testing methodologies quality standards metrics and accuracy control mechanisms and their application to software for differential equations linear algebra data analysis as well as the evaluation of integrals derivatives and elementary and special functions

*Numerical Validation in Current Hardware Architectures* Annie A.M. Cuyt, Walter Krämer, Wolfram Luther, Peter Markstein, 2009-04-24 The major emphasis of the Dagstuhl Seminar on Numerical Validation in Current Hardware Architectures lay on numerical validation in current hardware architectures and software environments The general idea was to bring together experts who are concerned with computer arithmetic in systems with actual processor architectures and scientists who develop use and need techniques from verified computation in their applications Topics of the seminar therefore included The ongoing revision of the IEEE 754 854 standard for floating point arithmetic Feasible ways to implement multiple precision multiword arithmetic and to compute the actual precision at run time according to the needs of input data The achievement of a similar behavior of fixed point floating point and interval arithmetic across language compliant implementations The design of robust and efficient numerical programs portable from diverse computers to those that adhere to the IEEE standard The development and propagation of validated special purpose software in different application areas Error analysis in several contexts Certification of numerical programs verification and validation assessment Computer arithmetic plays an important role at the hardware and software level when microprocessors embedded systems or grids are designed The reliability of numerical software strongly depends on the compliance with the corresponding floating point norms Standard CISC processors follow the 1985 IEEE norm 754 which is currently under revision but the new highly performing CELL processor is not fully IEEE compliant

**Computer Arithmetic and Validity** Ulrich Kulisch, 2013-04-30 This is the revised and extended second edition of the successful basic book on computer arithmetic It is consistent with the newest recent standard developments in the field The book shows how the arithmetic and mathematical capability of the digital computer can be enhanced in a quite natural way The work is motivated by the desire and the need to improve the accuracy of numerical computing and to control the quality of the computed results validity The accuracy requirements for the

elementary floating point operations are extended to the customary product spaces of computations including interval spaces. The mathematical properties of these models are extracted into an axiomatic approach which leads to a general theory of computer arithmetic. Detailed methods and circuits for the implementation of this advanced computer arithmetic on digital computers are developed in part two of the book. Part three then illustrates by a number of sample applications how this extended computer arithmetic can be used to compute highly accurate and mathematically verified results. The book can be used as a high level undergraduate textbook but also as reference work for research in computer arithmetic and applied mathematics.

**Software Verification** Maria Christakis, Nadia Polikarpova, Parasara Sridhar Duggirala, Peter Schrammel, 2020-12-05. This book constitutes the refereed proceedings of the 12th International Conference on Verified Software VSTTE 2020 and the 13th International Workshop on Numerical Software Verification NSV 2020 held in Los Angeles CA USA in July 2020. Due to COVID 19 pandemic the conference was held virtually. The 13 papers presented in this volume were carefully reviewed and selected from 21 submissions. The papers describe large scale verification efforts that involve collaboration, theory unification, tool integration and formalized domain knowledge as well as novel experiments and case studies evaluating verification techniques and technologies. The conference was co-located with the 32nd International Conference on Computer Aided Verification CAV 2020.

**Progress in Industrial Mathematics at ECMI 2010** Michael Günther, Andreas Bartel, Markus Brunk, Sebastian Schöps, Michael Striebel, 2012-04-05. ECMI the European Consortium for Mathematics in Industry is the European brand associated with applied mathematics for industry and organizes highly successful biannual conferences. In this series the ECMI 2010 the 16th European Conference on Mathematics for Industry was held in the historic city hall of Wuppertal in Germany. It covered the mathematics of a wide range of applications and methods from circuit and electromagnetic device simulation to model order reduction for chip design, uncertainties and stochastics, production fluids, life and environmental sciences and dedicated and versatile methods. These proceedings of ECMI 2010 emphasize mathematics as an innovation enabler for industry and business and as an absolutely essential prerequisite for Europe on its way to becoming the leading knowledge based economy in the world.

**Numerical Software with Guaranteed Results** Hongtao Wang, 1991. **Accuracy and Reliability in Scientific Computing** Bo

Einarsson, 2005-08-01. This book investigates some of the difficulties related to scientific computing describing how these can be overcome.

**Scientific Computing, Computer Arithmetic, and Validated Numerics** Marco Nehmeier, Jürgen Wolff von Gudenberg, Warwick Tucker, 2016-04-08. This book constitutes the refereed post proceedings of the 16th International Symposium SCAN 2014 held in Würzburg Germany in September 2014. The 22 full papers presented were carefully reviewed and selected from 60 submissions. The main concerns of research addressed by SCAN conferences are validation, verification or reliable assertions of numerical computations. Interval arithmetic and other treatments of uncertainty are developed as appropriate tools.

**Soft Methods for Integrated Uncertainty Modelling** Jonathan Lawry, Enrique Miranda, Alberto

Bugarin, Shoumei Li, Maria Angeles Gil, Przemyslaw Grzegorzewski, Olgierd Hryniewicz, 2007-10-08 The idea of soft computing emerged in the early 1990s from the fuzzy systems community and refers to an understanding that the uncertainty imprecision and ignorance present in a problem should be explicitly represented and possibly even exploited rather than either eliminated or ignored in computations For instance Zadeh defined Soft Computing as follows Soft computing differs from conventional hard computing in that unlike hard computing it is tolerant of imprecision uncertainty and partial truth In effect the role model for soft computing is the human mind Recently soft computing has to some extent become synonymous with a hybrid approach combining AI techniques including fuzzy systems neural networks and biologically inspired methods such as genetic algorithms Here however we adopt a more straightforward definition consistent with the original concept Hence soft methods are understood as those uncertainty formalisms not part of mainstream statistics and probability theory which have typically been developed within the AI and decision analysis community These are mathematically sound uncertainty modelling methodologies which are complementary to conventional statistics and probability theory *Applied Parallel Computing* Jack Dongarra, 2006-03-03 This book constitutes the refereed proceedings of the 7th International Conference on Applied Parallel Computing PARA 2004 held in June 2004 The 118 revised full papers presented together with five invited lectures and 15 contributed talks were carefully reviewed and selected for inclusion in the proceedings The papers are organized in topical sections *Data Modeling for Metrology and Testing in Measurement Science* Franco Pavese, Alistair B. Forbes, 2008-12-16 The aim of this book is to provide firstly an introduction to probability and statistics especially directed to the metrology and testing fields and secondly a comprehensive newer set of modelling methods for data and uncertainty analysis that are generally not considered yet within mainstream methods The book brings for the first time a coherent account of these newer methods and their computational implementation They are potentially important because they address problems in application fields where the usual hypotheses that are at the basis of most of the traditional statistical and probabilistic methods for example relating to normality of the probability distributions are frequently not fulfilled to such an extent that an accurate treatment of the calibration or test data using standard approaches is not possible Additionally the methods can represent alternative ways of data analysis allowing a deeper understanding of complex situations in measurement The book lends itself as a possible textbook for undergraduate or postgraduate study in an area where existing texts focus mainly on the most common and well known methods that do not encompass modern approaches to calibration and testing problems The book is structured in such a way to guide readers with only a general interest in measurement issues through a series of review papers from an initial introduction to modelling principles in metrology and testing to the basic principles of probability in metrology and statistical approaches to uncertainty assessment *The Palgrave Handbook of Operations Research* Saïd Salhi, John Boylan, 2022-07-07 Operations Research OR is a fast evolving field which is having a significant impact on its neighbouring disciplines of Business Analytics and Data Science and on contemporary business and

management practices This handbook provides a comprehensive and cutting edge collection of studies in the area Views differ on what should be included within the scope of OR The editors of this volume have taken the view that an inclusive stance is the most helpful both for theory and practice Real world problems often require consideration from both softer and harder perspectives and need consideration of both predictive and prescriptive problems In accordance with this inclusive approach to OR the book is divided into six parts covering Discrete Optimization Continuous Optimization Heuristic Search Optimization Forecasting Simulation and Prediction Problem Structuring and Behavioural OR and finally some recent OR Applications This wide ranging handbook includes a culturally diverse collection of authors with different perspectives and backgrounds around Operations Research It will be of tremendous value to researchers students and practitioners in the field of OR

*Static Analysis* Antoine Mine, David Schmidt, 2012-08-30 This book constitutes the thoroughly refereed proceedings of the 19th International Symposium on Static Analysis SAS 2012 held in Deauville France in September 2012 The 25 revised full papers presented together with 4 invited talks were selected from 62 submissions The papers address all aspects of static analysis including abstract domains abstract interpretation abstract testing bug detection data flow analysis model checking new applications program transformation program verification security analysis theoretical frameworks and type checking

#### **Integration of AI and OR Techniques in Constraint Programming for Combinatorial Optimization Problems**

Carla Gomes, Meinolf Sellmann, 2013-04-11 This volume is a compilation of the research program of the 10th International Conference on the Integration of Artificial Intelligence AI and Operations Research OR Techniques in Constraint Programming CPAIOR 2013 held at Yorktown Heights NY USA in May 2013 This volume contains 20 full papers and 11 short papers that were carefully reviewed and selected from 71 submissions The papers focus on new techniques or applications in the intersection of constraint programming CP artificial intelligence AI and operations research OR

*Software Verification* Roderick Bloem, Rayna Dimitrova, Chuchu Fan, Natasha Sharygina, 2022-02-21 This book constitutes the refereed proceedings of the 13th International Conference on Verified Software VSTTE 2021 and the 14th International Workshop on Numerical Software Verification NSV 2021 held online in July October 2021 Due to COVID 19 pandemic the conference was held virtually There were 10 papers presented in this volume were carefully reviewed and selected from 20 submissions The papers focuses on challenges of the verification of cyber physical systems with machine learning components and making large scale verified software a practical reality and much more

## **Numerical Software With Result Verification** Book Review: Unveiling the Magic of Language

In an electronic era where connections and knowledge reign supreme, the enchanting power of language has become much more apparent than ever. Its ability to stir emotions, provoke thought, and instigate transformation is truly remarkable. This extraordinary book, aptly titled "**Numerical Software With Result Verification**," written by a highly acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound impact on our existence. Throughout this critique, we shall delve into the book's central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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## Numerical Software With Result Verification Introduction

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