Implementation and application of extended precision in Matlab

Z.L. KROUGLY
Department of Statistical & Actuarial Sciences
The University of Western Ontario
London, Ontario, Canada
zkrougly@stats.uwo.ca

D.J. JEFFREY
Applied Mathematics
The University of Western Ontario
London, Ontario, Canada
djeffrey@uwo.ca

Abstract: A multiple precision library for floating-point calculations to any number of digits has been implemented in Matlab. The library is based on the ARPREC library. One application is discussed in detail, namely the evaluation in the complex plane of special functions in regions of bad conditioning. Through the use of Matlab classes, all the basic arithmetic operations are accessible using Matlab syntax, even though the fundamental operations are coded in C++. Arithmetic supports both real and complex data to arbitrary precision. The level of the precision being used can be changed at any time. Many elementary functions are also available in Matlab syntax, although not all of them are offered for complex arguments.

Key—Words: Arbitrary precision, special functions, condition number, Lambert W function

1 Introduction

Many applications in science require high accuracy beyond that which can be obtained using IEEE double precision. Applications which benefit from increased precision include simulations, power series, and solutions of nonlinear and differential equations. Recent applications to natural phenomena are contained in Boychuk *et al.* [4] and Krougly *et al.* [12], where extensive investigations of how the distribution selection for rate of spread and spotting distance will affect the spread of forest fire. Other applications are to sensitivity analysis, and stability and optimization techniques in nonlinear systems, such as closed network models (Krougly and Stanford [13]; Casale and Senazzi [7]).

The development of fundamental algorithms in IEEE double-double and quad-double floating point arithmetic was presented in Dekker (1971), Knuth (1998), Shewchuk (1997). One of the first multiple-precision packages was due to Brent (1978), and developed in Fortran 66. His package includes subroutines for evaluating elementary and special functions in multiple precision floating-point arithmetic. Brent's multiple precision package did not support complex arithmetic. Many basic properties of high-precision computations are implemented in the ARPREC software package (Borwein and Bailey, 2004, Bailey, 2002, 2005). Possibly that is the most comprehensive package in multiple-precision software. ARPREC software includes C++ and Fortran-90 modules, and can be downloaded from [1]. This package provides complex arithmetic and some complex elementary functions. Another well-known library is the GMP library, but this does not support many elementary functions.

For many engineers and mathematicians, MATLAB provides a familiar and efficient problem solving environment. Standard Matlab offers only double precision accuracy, and so for applications such as those described above, it would be beneficial to implement multiple precision facilities.

We have implemented a library for high-precision numerical calculations based on the ARPREC library. We have writing interface code, defined Matlab classes, and linked to a compiled form of the ARPREC source code. Thus, we enable programs written in Matlab syntax to access the ARPREC library and compute at any set precision.

2 Special function application

We now describe a specific motivating application. The evaluation of a real-valued function has been studied in great detail. In particular the conditioning of the problem is well understood. The theory for complex-valued functions is less well developed. We are interested in evaluation of the Lambert W function.

Lambert W function plays an important role in science and mathematics [8]. It is the inverse function of $f(w) = we^w$ where $w \in \mathbb{C}$, and it is multi-valued, being denoted by $W_k(z)$, where k is the branch number. The branches of the Lambert W function can be seen in Fig. 1.

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Implementation And Application Of Extended Precision In Matlab:

Numerical Computing with IEEE Floating Point Arithmeti Michael L. Overton,2025-05-29 This book provides an easily accessible yet detailed discussion of computer arithmetic as mandated by the IEEE 754 floating point standard arguably the most important standard in the computer industry The result of an unprecedented cooperation between academic computer scientists and industry the standard is supported by virtually every modern computer Although the basic principles of IEEE floating point arithmetic have remained largely unchanged since the first edition of this book was published in 2001 the technology that supports it has changed enormously Every chapter has been extensively rewritten and two new chapters have been added one on computations with higher precision than that mandated by the standard needed for a variety of scientific applications and one on computations with lower precision than was ever contemplated by those who wrote the standard driven by the massive computational demands of machine learning The second edition of Numerical Computing with IEEE Floating Point Arithmetic includes many technical details not readily available elsewhere along with many new exercises It explores the rationale for floating point representation correctly rounded arithmetic exception handling and support for the standard provided by floating point microprocessors and programming languages Key concepts such as cancellation conditioning and stability are also discussed The book emphasizes historical development from the early history of computing through the 2008 and 2019 revisions of the floating point standard to the latest advances in microprocessor support It also includes a previously unpublished letter by Donald E Knuth on the value of gradual underflow a key requirement of the standard This book should be accessible to any reader with an interest in computers and mathematics including students at all levels Some basic knowledge of calculus and programming is assumed in the second half There is enough variety of content that all but the most expert readers will find something of interest *Digital Signal Processors* Sen-Maw Kuo,Woon-Seng Gan,2005 This CD contains five appendices from the book and programs MATLAB Simulink C and TMS320C5000 assembly with their associated data files **A Primer on Radial Basis Functions with Applications to the Geosciences** Bengt Fornberg,Natasha Flyer,2015-09-30 Adapted from a series of lectures given by the authors this monograph focuses on radial basis functions RBFs a powerful numerical methodology for solving PDEs to high accuracy in any number of dimensions This method applies to problems across a wide range of PDEs arising in fluid mechanics wave motions astro and geosciences mathematical biology and other areas and has lately been shown to compete successfully against the very best previous approaches on some large benchmark problems Using examples and heuristic explanations to create a practical and intuitive perspective the authors address how when and why RBF based methods work The authors trace the algorithmic evolution of RBFs starting with brief introductions to finite difference FD and pseudospectral PS methods and following a logical progression to global RBFs and then to RBF generated FD RBF FD methods The RBF FD method conceived in 2000 has proven to be a leading candidate for numerical simulations in an increasingly wide range of

applications including seismic exploration for oil and gas weather and climate modeling and electromagnetics among others This is the first survey in book format of the RBF FD methodology and is suitable as the text for a one semester first year graduate class **Biomedical Applications of Light Scattering** Adam Wax,Vadim Backman,2009-09-22 Clinical applications include detecting pre cancerous and cancerous tissue states characterizing cell and tissue properties for identifying disease and assessing the presence and concentration of biochemicals for diagnostic purposes Part of the McGraw Hill Biophotonics Series   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 merical 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 gor in the de nition 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 al rithms with controlled rounding and result veri cation capture uncertainty in modeling and problem formulation in model parameter estimation in algorithm truncation in operation round o and in model interpretation The techniques of validated computing have proven their merits in many scienti c and engineering applications They are based on solid and interesting theoretical studies in mathematics and computer science Contributions from elds including real complex and functional analysis semigroups probability statistics fuzzyintervalanalysis fuzzylogic automaticdi erentiation computer hardware operating systems compiler construction programming languages object oriented modeling parallel processing and software engineering are all essential   Proceedings of the International Conference on Electromagnetic Interference and Compatibility ,2003   **The DSP Handbook** Andrew Bateman,Iain Paterson-Stephens,2002 CD ROM contains a series of applications which have veen designed to support the differenct topics covered   Wescon ... Conference Proceedings ,1996   Advanced Mathematical And Computational Tools In Metrology And Testing X Franco Pavese,Wolfram Bremser,Anna G Chunovkina,Nicolas Fischer,Alistair B Forbes,2015-04-22 This volume contains original and refereed contributions from the tenth AMCTM Conference www nviim ru AMCTM2014 held in St Petersburg Russia in September 2014 on the theme of advanced mathematical and computational tools in metrology and testing The themes in this volume reflect the importance of the mathematical statistical and numerical tools and techniques in metrology and testing and also keeping the challenge promoted by the Metre Convention to access a mutual recognition for the measurement standards   *Conference Record* ,1996   **Periodica Polytechnica** ,1999   **Digital Signal Processing Applications** ,1999   FCCM 2004 Jeffrey Arnold,Kenneth L. Pocek,2004 FCCM presents recent work on the use of reconfigurable logic as

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web based on the user commands the robot moves and pick and place the objects the robotic arm used here is similar to a human arm which is programmed to perform the pick and place functions the remainder of this paper is organized as follows the section 2 provides information about the existing works section 3 gives details of the proposed

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