Presentations of Mathematical Software

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CoCoA

Anna Maria Bigatti, Lorenzo Robbiano
Università di Genova

Tuesday, 17.00 – 17.30, Room 11

CoCoA is a special-purpose system for doing COmputations in COmmutative Algebra. It runs on all the most popular platforms (Windows, Linux, MacOS, LinuxPPC, Sun Unix, Digital Unix,...) and includes complete on-line and html help.

CoCoA's principal area of expertise is that of operations over commutative rings of polynomials. For example, it can readily compute Gröbner Bases, syzygies and minimal free resolutions, ideal and module intersections, the radical of an ideal, the defining ideals of 0-dimensional schemes, Poincaré series and Hilbert functions, factorization of polynomials, toric ideals.

The capabilities of CoCoA and the flexibility of its use are further enhanced by the dedicated high-level programming language.

CoCoA is also used as the main system for research and for teaching advanced courses in several Universities in Europe and in America.

In this presentation we describe the main features of CoCoA and show some concrete examples of use.

More detailed information about the system can be found at the following web address:

`http://cocoa.dima.unige.it/`

The LINSOL program package: Iterative solution of large (sparse) linear systems on distributed memory systems

Hartmut Häfner, Willi Schönauer
Rechenzentrum der Universität Karlsruhe

Tuesday, 17.00 – 17.30, Room 12

LINSOL solves huge linear systems. It is adapted to the application of sparse matrices, but alike it can be used efficiently applied to full matrices. As the useage of main memory strongly increases when applying direct solvers to sparse matrices, iterative algorithms are employed. Most of the well-known methods like PRES20, BCG, BiCGSTAB, BiCGSTAB(2), CGS, BICO, QMR, CGNE (ATPRES), GMERR and the classical CG-algorithm are implemented. The iterative methods can additionally be preconditioned by a (incomplete) LU-decomposition applied to the "skyline" of the matrix. Before executing the elimination process the bandwidth of the matrix is reduced by a bandwidth optimizer. All the above mentioned algorithms can run in parallel on distributed memory parallel computers.

Important features of the program package are

- robustness,
- portability,
- flexibility
- and the efficient implementation on workstations, vector computers and parallel computers.

To obtain portability and flexibility of the code the FORTRAN 90 standard is kept and the message passing paradigma is used on parallel computers; beyond that, an own, minimal

message passing interface is defined enabling the user to put in all available message passing libraries in the link step of the program package.

Flexibility with respect to the integration of the program package into an application is obtained by the support of many common storage patterns for sparse matrices. In all, 8 storage patterns are placed at the user's disposal; the most important are: diagonal, row, column —always full and packed— and double index.

LINSOL is optimized for workstations, vector computers and parallel machines with regard to both the time requirements and the storage requirements.

The LINSOL program package is public domain software running on all UNIX-based systems. For the use of LINSOL on more than one processor MPI or PVM or another message passing software is used. The field of application is the numerical simulation; thus the targeted user community are engineers working with numerical simulation software. The software is written in FORTRAN 90 and uses the message passing paradigma for the use on parallel computers. LINSOL is an integral part of the program package FDEM solving partial differential equations with the Finite Difference Element Method (FDEM), see paper by T. Adolph at this conference.

Internet learning math

Davor Cengija, Mario Essert
Faculty of Mechanical Eng. & Naval Architecture, Zagreb

Tuesday, 17.00 – 17.30, Room 8

This project is attempting to show how some real (and not trivial) tasks can be transferred to the Web, using different, mostly freely available tools for Linux (PHP scripts, PHPLib, MySQL database server, Matcom compiler and GNUPlot). Because of advances in software it is now possible to design learning tools with much better man machine interaction, with intuitive graphical user interfaces and a high degree of interactivity. To give the tools a high pedagogical value, we have implemented learning environment as a collection of small modules (Matrix calculator, Control system functions on Web, GNUPlot on Web, Jorbology,. . .) which grows daily. We have found that this approach can be very useful for teaching and studying mathematics and control system theory. Therefore we hope that it will find place in our new educational system in a very near future. Demo versions are accessible at

`http://mcs.hr/~dcengija/math`

or

`http://zrno.fsb.hr/math/`

Acknowledgement. We are grateful to Prof. Dr. Kresimir Veselic at the Fern Universität Hagen who directed us into this interesting area.

Newton: A package for prime decomposition in number fields

Jordi Guàrdia, Jesús Montes
Universitat de Barcelona

Tuesday, 17.45 – 18.15, Room 11

`Newton` is a Mathematica package designed to decompose prime integers in number fields. It is based on a very efficient algorithm of Montes ([2]). With the package on hand, we have been able to decompose primes in a field of degree 512 in a hundred minutes ([1]).

The algorithm of Montes is a beautiful application of Newton polygons to number theory. Empirically, its results improve largely the results obtained with classical *global* methods.

The package contains functions to perform each of the basic steps in Montes' algorithm, including generalized Taylor series and construction of Newton polygons. It makes hard use of `FiniteFields`, a second package designed by the author to use finite fields in Mathematica.

References

[1] J. Guàrdia, *Geometria Aritmètica en una família de corbes de gènere 3*, Thesis, Univ. de Barcelona (1998).

[2] J. Montes, *Polígonos de Newton de orden superior y aplicaciones aritméticas*, Thesis, Univ. de Barcelona (2000).

The FDEM (Finite Difference Element Method) program package: Black-box solver for elliptic and parabolic PDEs

Torsten Adolph, Willi Schönauer
Rechenzentrum der Universität Karlsruhe

Tuesday, 17.45 – 18.15, Room 12

The FDEM program package is a black-box solver for nonlinear systems of algebro partial differential equations with arbitrary nonlinear boundary conditions. It is based on a finite difference method of arbitrary consistency order (for practical reasons the order is restricted to $q = 2, 4, 6$) on an unstructured FEM grid with error estimate and selfadaption of consistency order (individual in each grid point) and mesh size, so it combines the advantages of the FDM (easy access to the local and global error, arbitrary consistency order, direct solution of the PDEs, not by a corresponding functional equation) with those of the FEM (arbitrary geometry by the flexibility of unstructured grids). The generation of the difference and error formulae is done by an intelligent selection of appropriate mesh points. 2- and 3-dimensional systems of elliptic (stationary) and parabolic (time-dependent) systems can be solved. The method is fully parallelized on distributed memory parallel computers.

The FDEM program package is public domain software running on all UNIX-based systems. For the use of FDEM on more than one processor MPI or PVM or another message passing software is used. The field of application is the numerical simulation, so the targeted user community are engineers that deal with numerical simulation software. The software is written in FORTRAN 90 and uses the message passing paradigma for the use on parallel computers. FDEM uses the iterative solver package LINSOL for the solution of the large sparse linear system that results from the discretization, see paper by H. Häfner at this conference.

MathType by design science

Bob Mathews
California State University, Long Beach

Tuesday, 17.45 – 18.15, Room 8

MathType 4.0 is the latest release of Design Science's interactive mathematical equation editing software package, the full-featured version of the Equation Editor applet that comes with Microsoft Word. MathType is a tool that is used with a word processor or presentation program to add mathematical notation to documents or screen presentations. This session is appropriate for teachers of middle grades and up, as well as scientists and engineers working in industry and government positions.

Traditionally, authoring a scholarly paper or technical document has been a challenge. Techniques are available that produce a high quality product, but these methods generally have a steep learning curve and high error potential. MathType solves these problems by providing a simple point-and-click interface. Expressions created in MathType can be inserted directly into a word processing document or presentation. Alternatively, the expressions can be translated into a typesetting language such as TEX or LATEX, a markup language such as MathML, or can be saved as graphic files.

The presenter will use MathType with Microsoft Word and PowerPoint to show how to create professional mathematical and scientific documents and presentations. He will also demonstrate how to use MathType to include formulas and technical expressions in Web documents. The attendee will leave with an appreciation of how MathType can meet the needs of educators, mathematicians, and scientists worldwide.

SINGULAR: A computer algebra system for polynomial computations

Gerd-Martin Greuel, Gerhard Pfister, Hans Schönemann
Universität Kaiserslautern

Tuesday, 18.30 – 19.00, Room 11

SINGULAR is a computer algebra system for polynomial computations with emphasize on the special needs of commutative algebra, algebraic geometry, singularity theory, and polynomial system solving.

SINGULAR's main computational objects are polynomials, ideals and modules over a large variety of rings. SINGULAR features one of the fastest and most general implementations of various algorithms for computing standard bases. Furthermore, it provides multivariate polynomial factorizations, resultant, characteristic set and gcd computations, syzygy and free-resolution computations, and many more related functionalities.

Based on an easy-to-use interactive shell and C-like programming language, SINGULAR's internal functionality is augmented and user-extendible by libraries written in the SINGULAR programming language. Among others, SINGULAR has libraries which implement primary decomposition, Hamburger-Noether development, ring normalization, monodromy computation, and polynomial system solving.

SINGULAR is publicly available as a binary program for all common Unix platforms, for Windows 95/98/NT and for MacOS. It can be downloaded by anonymous ftp from

`ftp://www.mathematik.uni-kl.de/pub/Math/Singular`

For more and always up-to-date information, SINGULAR's WWW home page can be reached at

`http://singular.mathematik.uni-kl.de`

Mathematical software for anylizing complex societal problems

Alexander Makarenko
National Technical University of Ukraine (KPI)

Tuesday, 18.30 – 19.00, Room 12

Now all recognized the needs of solving societal problems on strict scientific base. Earlier the author proposed entirely new mathematical models with associative memory property. The mathematical software for application of such models is proposed. Computer programs for next problems are considered:

1. Modeling of geopolitical relations and future World order. Some realization of new neuronet approach is proposed for prognosing.

2. Demography problems in many regional aspects. It is proposed computer program with accounting space and time aspects of stored data.

3. Modeling of election processes. It is proposed computer program with accounting space and time aspects of stored data. The program includes the space —time data— base on election, demographic, political information with developed tools for visualization of results in geoinformational systems.

4. Multivaluedness in societal problems. Results on modeling of multivalued neurons will be displayed.

5. Complexity measure of individual objects. The definition of complexity was proposed based on the amount of symmetry in the objects. The computer program for recognition will be proposed. The software was developed for personal computers and Windows media.

Levkov S., Makarenko A., *Geopolitical relations in post USSR Europe as a subject of mathematical modelling and control.* Proc.7 IFAC/IFORS/IMACS Symp:LargeScalesSyst. L. UK: Vol. 2., 1995. p. 983–987.

Makarenko A., *New Neuronet Models of Global Socio-Economical Processes.* In 'Gaming/Simulation for Policy Development and Organisational Change' (J. Geurts, C. Joldersma, E. Roelofs eds), Tillburg University Press, 1998.

GRAMMARKOV: A Markov chain application to probabilistic linear grammars

Inmaculada Fortes, F. J. González, Rafael Morales-Bueno,
José Luis Pérez de la Cruz, F. Triguero
Universidad de Málaga

Tuesday, 18.30 – 19.00, Room 8

Probabilistic linear grammars are used in the field of syntactic pattern recognition. To decide if two linear grammars generate the same language is a NP-complete problem. The general goal of this software is the study of the statistical features of probabilistic linear grammars by means of Markov chains. The statistical study of her Markov chain associated arises light about the language features. We present an application of Markov Chains to extract non-trivial and useful information about the characteristics of probabilistic linear grammars.

The implementation of the software has been done in a PC computer and Borland Delphi 3.0 compiler. The software is an MDI (Multiple Document Interface) application developed in Windows 98 which allows good control in the modular development. The design of the algorithms has been performed using the resources and memory to make the most of ability of computing. This software aims to be a helpful and flexible tool for the user. Special care has been taking concerning user-friendness and error handling. Besides, proofs of the optimal running of the algorithm have been executed.

The software allows two types of inputs: probabilistic linear grammars and specifically Markov Chains. In both cases statistical features will be computed and the results are available in a file.

A version of this software is available in the Web

`http://www.ctima.uma.es/matap/personal/ifortes/grammarkov.html`

The person who is going to make the presentation is Inmaculada Fortes Ruiz.

CREP

Peter Dräxler, Rainer Nörenberg
Universität Bielefeld, Universität Essen

Thursday, 17.00 – 17.30, Room 11

CREP stands for Combinatorial REPresentation theory. The objective of the CREP system is to work with finite-dimensional associative algebras or better finite-dimensional categories and their representations. Path categories of quivers (i.e. directed graphs) usually equipped with additional combinatorial data serve as algorithmic domain to realize and implement these algebraic objects.

The intention was to design a system which supports present research and can also be used for teaching. The implementation should not require to write a complete new system but an existing computer algebra system should be used to provide the user interface, the help system, the format of the manuals and the basic procedures. On the other hand it had to be ensured that related programs originally developed independently at different places and in various programming languages could be integrated without the necessity of expensive recoding. Finally, there had to be appropriate input and output devices to visualize the various graphical data which are typical for the subject.

We think that we rather successfully met these requirements by writing a system which for the user looks like a package of Maple procedures using all the convenient facilities of this computer algebra system but by external calls refers to programs written in Pascal, C and C++. Moreover, for visualization a graphical tool package called Xforms and recently also Java applications are invoked.

More details about CREP can be found in the web under the URL

`http://www.mathematik.uni-bielefeld.de/birep/crep.html`

where you will also find a Java applet allowing you to try a typical procedure with your browser.

Time-delay system toolbox

Soo Hee Han, Arkadii Kim, Wook Hyun Kwon, Andrew Lozhnikov, Olga Onegova, Vladimir Pimenov
Seoul National University

Thursday, 17.00 – 17.30, Room 12

TIME-DELAY SYSTEM TOOLBOX provides support for numerical simulation of linear and nonlinear systems of *functional differential equations* (time-delay systems) with discrete and distributed (possibly time-varying) delays.

Additionally, for engineering applications, TOOLBOX contains programs for time-domain analysis of linear time-delay systems and the analytic design technique of linear quadratic regulator.

The new numerical and control algorithms, realized in TOOLBOX, are direct generalization of the corresponding methods of ordinary differential equations (ODEs), i.e. if delays disappear then the algorithms coincide with the corresponding numerical and control algorithms for ODEs.

The present version of the software package works under MATLAB environment.

A computer program for algebraic topology

Xavier Dousson, Julio Rubio, Francis Sergeraert, Yvon Siret
Université de Grenoble

Thursday, 17.45 – 18.15, Room 11

Classical Algebraic Topology is well known not to be effective. The classical "tools" (exact and spectral sequences) *are not* algorithms and in general do not allow, even from a theoretical point of view, to reach homology, homotopy, K-theoretic... groups. The paper *The computability problem in algebraic topology* (F. S., Adv. in Math., 1994, vol. 104, pp. 1–29) describes a general framework overcoming this essential difficulty. The *Kenzo* program is the first concrete realization with a large scope following the ideas initiated in this paper.

The main objects that can be handled with the Kenzo program are: *Chain complexes*, of finite type or not; Differential graded *Algebras* and *Coalgebras*, *Hopf* algebras, of finite type or not; *Simplicial sets*, finite or not, possibly with a Kan structure; *Simplicial Groups*; *Morphisms* of various types between these objects; Simplicial *Fibrations*; *Bar* and *Cobar* constructions; *Loop Spaces*; *Classifying spaces*; *Eilenberg-MacLane* spaces; *Serre* and *Eilenberg-Moore* spectral sequences.

The Kenzo program allowed us in particular to reach many homology groups of various loop spaces otherwise so far not reachable. Furthermore, combining the Serre and Eilenberg-Moore spectral sequences available in the Kenzo program, the first *homotopy groups* of an *arbitrary* simplicial set may be computed.

The Kenzo program is freely available at:

`www-fourier.ujf-grenoble.fr/~sergerar`

Mathematical visualization and online experiments with JavaView

Konrad Polthier
Technische Universität Berlin

Thursday, 17.45 – 18.15, Room 12

JavaView is a mathematical visualization software for scientific research in geometry and numerics, for mathematical education and for the publication of interactive mathematical experiments. JavaView includes a numerical software library for creating new experiments and has a powerful 3D geometry viewer. The most distinguished feature of JavaView is the possibility to perform sophisticated mathematical experiments simultaneously online in interactive web pages and as applications on local computers.

In the talk we use examples from differential geometry to discuss practical aspects of online publications and give technical details on the ease of implementations. We present sample interactive documents with visualization examples, report on the work on a multimedially enhanced reference dissertation in mathematics, and show different numerical online experiments from ongoing research activities.

Further information:

`http://www-sfb288.math.tu-berlin.de/vgp/`

Construction of algebraic-geometric codes in Magma

Lancelot Pecquet
Université de Rocquencourt

Thursday, 18.30 – 19.00, Room 11

Magma is a non-commercial computer algebra system —successor of the group theory system *Cayley* (1975)— developed since 1993 at the University of Sydney, Australia, under the direction of Dr. John Cannon.

It provides a unified environment to work in many areas of algebra, including group theory, linear algebra, rings, fields, number theory, modules, algebraic geometry, graphs, designs, coding theory, *etc.* It can be used for research, but also for teaching mathematics and computer science. For both, it has many advantages on other symbolic computation systems. Magma is strongly typed, based on category theory and universal algebra. The language is very expressive and thus the syntax is concise and powerful. It features all basic algebraic objects, like groups, polynomials, matrices, graphs,... It is therefore very easy to use it in courses to describe algorithms and make student manipulate algebraic objects easily. Moreover, Magma features, as well, many sophisticated algebraic constructions, like number fields and their orders, lattices, codes, designs, Lie algebras, elliptic curves,... Last but not least, Magma is, from far, the fastest computer algebra system available.

The talk will be a general introduction to Magma through an example of a concrete realization involving several algebraic objects: the construction of GOPPA's Algebraic-Geometric Codes. Given a plane projective curve over a finite field, after having blown-up the singularities, and found the places of degree 1 of its function field, the BRILL-NOETHER algorithm will allow to find the RIEMANN-ROCH space of the divisor of the code and to build a generator matrix.

REFERENCES

[1] W. Bosma and J. Cannon, *Handbook of Magma functions*. Comes with the system.
See `http://www.maths.usyd.edu.au:8000/u/magma/`.

[2] L. Pecquet, *An Introduction to Magma, the Computer Algebra System*, Springer-Verlag, 2000. to appear.

Polymake: A software environment for the investigation of polyhedra

Ewgenij Gawrilow, Michael Joswig
Technische Universität Berlin

Thursday, 18.30 – 19.00, Room 12

Polymake is a software system for the algorithmic treatment of polyhedra. Polymake is intended for researchers who are interested in polyhedral geometry and linear optimization. At the same time polymake is used for students' education.

Polyhedra can be built from user input data, such as set of point or hyperplane coordinates, or purely combinatorially via vertex-facet incidence matrix; they can be generated as parameterized representatives of many standard families of polytopes (simplices, cubes, cyclic polytopes, etc.); new polyhedra can be constructed from other ones using numerous transformations and manipulations (dualization, intersection, minkowski sum, etc.)

For a given polyhedron, various properties can be studied, especially combinatorial ones (simplicial, cubical, neighborly, etc.). Three- and four-dimensional polytopes can be visualized directly and via Schlegel diagrams, respectively.

The primary design goal of polymake is its openness and its extendibility, allowing to customize the software to the specific needs of the researcher. C++ and perl APIs are offered. The former allows to seamlessly embed new algorithms into the existing installation, while the latter provides a mighty data conversion tool used by integration of external software packages into the polymake framework. In the fact, a lot of polymake functionality is accomplished by software tools developed by other research groups, the most important of them being the convex hull computation algorithms cdd (ETH Zürich) and lrs (McGill University), as well as the visualization tools javaview (TU Berlin) and graphlet (Passau University).

Polymake is free software, it can be downloaded from the project homepage:

`http://www.math.tu-berlin.de/diskregeom/polymake/`