Prof. Keith O. Geddes
David R. Cheriton School of Computer Science,
University of Waterloo, Canada

Generating Efficient Numerical Evaluation Routines for Bivariate Functions via Tensor Product Series

Given a bivariate function f(x, y), we consider the problem of generating, in an automated manner, a routine for efficient numerical evaluation at any point in a specified rectangular region of the x-y plane. The goals for the generated routine are: accuracy (for a specified fixed precision), efficiency, and the generated routine must be “purely numerical” in the sense that it can be translated into a language such as C and can be compiled for inclusion in a numerical library. For example, we are able to generate numerical evaluation routines for the various Bessel functions (with the order treated as a real-valued variable), and other bivariate functions, with significantly increased speed of evaluation compared with current implementations. We exploit the capabilities of a computer algebra system to achieve the desired level of automation. A fundamental tool in our method is the natural tensor product series developed in a doctoral thesis by Frederick W. Chapman in 2003. Using this technique, f(x, y) is approximated by an interpolation series such that each term in the series is a tensor product cigi (x)hi (y). The efficiency of approximation achieved by this method derives from the fact that the univariate basis functions are cross-sections of the original bivariate function. The bivarate approximation problem is thereby reduced to a sequence of univariate approximation problems which can be handled by various well-known techniques. Assuming that the univariate basis functions are analytic with isolated singularities, we apply singularity-handling techniques to ensure the efficiency of the univariate approximations.

Prof. Wolfgang Hackbusch
Max-Planck-Institute of Mathematics, Leipzig, Germany

Efficient convolution with the Newton potential in d dimensions

The paper is concerned with the evaluation of the convolution integral of a function f with the Newton potential 1/||x|| in R^d (usually d=3), when f is given as piecewise polynomial of possibly large degree, i.e., f may be considered as an hp-finite element function.

The underlying grid is locally refined using various levels of dyadically organised grids. The result of the convolution is approximated in the same kind of mesh. If f is given in tensor product form, the d-dimensional convolution can be reduced to one-dimensional convolutions.

Although the details are given for the kernel 1/|x|, the basis techniques can be generalised to homogeneous kernels, e.g., the fundamential solution const*|x|^{2-d} of the d-dimensional Poisson equation.

Prof. Erich Kaltofen
Department of Mathematics and Department of Computer Science
North Carolina State University, USA

Title: The Discovery of Reduced Symbolic Models and the Seven Dwarfs of Symbolic Computation

The reconstruction of a function from a set of observed or computed data points goes back at least to Gauss's least squares curve fitting. A significant contribution of symbolic computation are algorithms for the recovery of sparse polynomial models [Giesbrecht, Labahn, Lee 2003-6] and of sparse rational function models [Kaltofen, Yang, Zhi 2007] from reduced sets of data points. The underlying algebraic, randomized algorithms are hybridized for noisy input data, thus complicating the probabilistic analysis as the random projections now must avoid ill-conditioned subproblems rather than exact singularities. We will discuss the arising problems in random matrix theory, and present the additional example of solving highly overdetermined dense linear systems in nearly optimal complexity.

At http://view.eecs.berkeley.edu/wiki/Dwarf_Mine a Berkeley author team proposes 13 "Dwarfs" (methods) of scientific problem solving. Kathy Yelick has indicated to me that Symbolic Computation is another dwarf. I shall propose 7 "(sub)Dwarfs" of Symbolic Computation and their role in model discovery.

Prof. Hermann G. Matthies
Institute of Scientific Computing
Technical University Braunschweig, Germany

White Noise Numerical Methods for Stochastic Partial Differential Equations

In physical systems described by partial differential equations, uncertainty is often modelled by allowing random fields as coefficients, resulting in stochastic partial differential equations. While traditionally the Monte Carlo method or one of its variants has been the standard tool to use on such problems, recently there is increased activity regarding the use of so-called stochastic Galerkin/collocation methods. These allow a different and new view on the problems alluded to before, and also make a connection to white noise stochastic analysis.

In the talk, these methods and their interconnections with other research areas will be presented, as well as their relation and advantages/disadvantages regarding the more traditional Monte Carlo methods.

Prof. Tomas Recio

University of Cantabria, Santander, Spain

Automated Deduction in Geometry through Symbolic Computation

This talk aims to present a reflection on the status (past, present, future) of Automated Deduction in Geometry through Symbolic Computation, with the occasion of the twentieth anniversary of the publication of Chou's "Mechanical geometry theorem proving" (1988), and thirty years after Wu's "On the decision problem and the mechanization of theorem-proving in elementary geometry" (1978)", two paradigmatic references on the topic.

Prof. Henk van der Vorst
Mathematical Institute, University of Utrecht, The Netherlands

Linear Algebra and Computers
An upward spiral

Numerical linear algebra plays a very dominant role in scientific computing. Many realistic models lead to the necessity to solve very large linear systems of unknowns, with, say, billions of unknowns, or to solver very large eigenproblems. The standard methods are not suitable for these tasks and new methods had to be developed over time: a still ongoing research. We observe a kind of spiral. Faster computers lead to larger systems and this requires faster methods. These faster methods are also used to model electronic devices, which are necessary to build faster computers. In this presentation we will see examples of this for various applications, and we will also see some new trends in scientific computing research