the error cannot be controlled in the course of the solution: we must stick with an initial step length through thick and thin. Abandonment of symplecticity, on the other hand, spoils the qualitative picture, denies us the benefits of backward error analysis and in long-term integration brings about considerably faster accumulation of error. The authors debate this dilemma at some length and conclude that, provided the solution interval is relatively short, good (nonsymplectic) Runge-Kutta methods, e.g., the Dormand-Prince algorithm, have the edge. However, there is little doubt that symplectic methods are superior when it comes to long-term integration.

The authors conclude with a long list of additional themes and extensions—generating functions, the Lie formalism, the Poisson bracket, generation of high-order symplectic Runge-Kutta... .

This is an important book on an important subject. As numerical analysis evolves, we are likely to witness growing interdependence of numerical and dynamical considerations. Numerical Hamiltonian equations are a showcase of this meeting of ideas and cultures, but its eventual influence is bound to spread significantly wider. No numerical analyst can afford to stay ignorant of this trend.

A. ISERLES

Department of Applied Mathematics and Theoretical Physics
University of Cambridge
Cambridge CB3 9EW
England

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**26[65F10, 65-04].**—RICHARD BARRETT, MICHAEL BERRY, TONY F. CHAN, JAMES DEMMEL, JUNE DONATO, JACK DONGARRA, VICTOR EIJKHOUT, ROLDAN POZO, CHARLES ROMINE & HENK VAN DER VORST, *Templates for the Solution of Linear Systems: Building Blocks for Iterative Methods*, SIAM, Philadelphia, PA, 1994, xiv + 112 pp., $25\frac{1}{2}$ cm. Price: Softcover \$18.00.

In 1971 James Wilkinson and Christian Reinsch edited a handbook of ALGOL programs for the solution of linear systems and eigenvalue problems [4]. The individual contributions had been previously published in *Numerische Mathematik* and were characterized by painstaking attention to detail, extensive testing, and complete documentation of both the algorithms and their implementations. Although the programming language ALGOL never caught on in the United States, the Handbook had an enormous influence on the later development of mathematical software. For my generation it was the place to turn to discover how to implement matrix algorithms. In addition it was the inspiration for a series of linear algebra packages: EISPACK [3] (a FORTRAN translation of the Handbook eigenvalue algorithms), LINPACK [2], and LAPACK [1].

The authors of the book under review are concerned that such packages do not serve all customers equally well. The packages, they claim, work well for people who want black boxes but not for people who want customized code for specialized applications. They go on to say that both groups can be satisfied by introducing templates. In their own words:

> A template is a description of a general algorithm rather than the executable object code or the source code more commonly found in a conventional software library. Nevertheless, although templates are general descriptions of key algorithms, they offer whatever degree of customization the user may desire. For example, they can be configured for the specific data structure of a problem or for the specific computing system on which the problem is run.

These claims, I believe, are not supported by the present volume, even for the simply structured iterative algorithms the authors consider. But by the way of compensation, the authors have produced a very useful survey of iterative methods circa 1994. For reasons I will get to later, I think any attempt to produce a set of templates will lead one willy-nilly into writing a survey. But for now, I will forget templates—the word itself does not seem to appear between the introduction and the appendices—and review the book as if it were titled *Iterative Methods for Linear Systems: An Algorithmic Survey.*

The meat of the book is contained in four chapters entitled Iterative Methods, Preconditioners, Related Issues, and Remaining Topics.

The chapter on iterative methods is devoted to describing the basic algorithms. The authors make the usual distinction between stationary methods, such as the Gauss-Seidel method, and nonstationary methods, such as the conjugate gradient method. Each method is illustrated by pseudocode consisting of a pleasing mix of mathematical notation and flow control. The coverage is quite complete, and the chapter is especially valuable as an introduction to Krylov methods for nonsymmetric systems, a hot topic at the moment. A regrettable omission is a treatment of look-ahead techniques, since some of the algorithms are not really functional without them. The chapter concludes with a well-organized summary.

The chapter on preconditioners is a concise survey. It treats Jacobi and block Jacobi preconditioners, incomplete factorization methods, and preconditioners based on underlying differential equations.

The chapter on related issues treats stopping criteria, data structures, and parallelism. The section on stopping criteria is highly technical and I think will prove more confusing than useful to the nonexpert. Little is said about what convergence criteria are suitable for specific algorithms, and the introduction may mislead some into thinking that an explicit residual computation must be done each time convergence is checked. The section on data structures, on the other hand, is a much needed survey of some of the conventions used in handling sparse matrices. Parallelism is a difficult topic, and the authors have handled it as well as they can in a small book. This section is really a collection of broad hints with references to the literature.

The last chapter is a miscellany, treating topics like domain decomposition and multigrid methods. The book concludes with three appendices, a glossary, and a bibliography with over two hundred entries.

The authors and their publisher, SIAM, are to be commended for making the book and its algorithms available electronically. The book itself suffers from minor lapses that are inevitable in a first edition. Moving some of the introductory material on preconditioning to the beginning of the chapter on iterative methods would help orient the reader. The highly technical term "gather" is introduced without definition. Some of the terms in the glossary did not make it to the index. But these are minor matters, easily corrected in the electronic version. I found the book an invaluable companion when I was teaching iterative methods, and I highly recommend it to anyone who has anything to do with the subject.

I cannot, on the other hand, recommend the idea of a template, at least as it is found in the present volume. There are three reasons. It is not new. It does not perform as advertised. And it represents a falling off from a high tradition.

The fact that templates are not new is easily seen by imagining someone reading the second chapter on iterative methods in isolation. He or she would have no idea that it was anything other than a standard exposition of the kind found in a book on matrix computations. True, theoretical aspects are not prominent and the pseudocode is in some cases slightly more elaborate than usual. But that can be accounted for by the algorithmic orientation of the authors. Without being told, our reader would never guess that a new idea had informed the exposition.

Regarding performance, the authors' assertion (see above) that their algorithms can be configured for the data structure in question is largely correct. But this says more about the simplicity of the matrix operations required to implement iterative methods than about the effectiveness of templates in general. In particular, the iterative methods treated here require nothing more than that the matrix operate on a vector, or some equally simple operation, which can be left to the user to implement. But it is hard to imagine a template for, say, an LU decomposition that permits the easy passage from a dense to a sparse matrix.

On other counts the templates do not fare as well. The authors evidently regard convergence checking as an implementation detail and lard their pseudocode with the statement "check convergence; continue if necessary." The user is presumably to go to the section on stopping criterion and figure out what to do. But it is not at all clear that anyone but an expert could arrive at a proper convergence test from the material presented there.

When the going gets tough, the authors punt. Regarding look-ahead strategies, they say, "This leads to complicated codes and is beyond the scope of this book." In treating the QMR method, which really needs look-ahead, they refer the reader to a black-box "professional implementation." If templates cannot handle this comparatively simple situation, how will they fare with more complicated algorithms—say a quasi-Newton optimization method?

All this, I believe, explains why the present book ended up as a survey. If you are going to publish algorithms abstracted from their implementations—the definition of template in the glossary—and still expect the user to arrive at working code, you have to give hints about how to write it. In this case the hints have expanded to fill three of the four substantive chapters of the book.

The scientific community has been well served by the tradition that spawned the Handbook, EISPACK, LINPACK, and LAPACK. Because of the exhaustive documentation of the first three packages—LAPACK provides only documentation on usage, not on algorithmic and implementation details—they have been studied and modified by people who want to learn and customize. They are in fact the true templates of numerical linear algebra, and it would be a shame if the best and brightest were to desert the tradition. As I said earlier, the authors have produced a very useful book that is worthy of wide distribution. But the reader should keep in mind that the best template is carefully crafted, thoroughly documented working code.

G. W. S.

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**27[40A15, 30B70, 42C05, 33B15, 30E05].**—S. Clement Cooper & W. J. Thron (Editors), *Continued Fractions and Orthogonal Functions: Theory and Applications*, Lecture Notes in Pure and Appl. Math., vol. 154, Dekker, New York, 1994, xiv + 379 pp., 25 cm. Price: Softcover $145.00.

The birth and early development of the general theory of orthogonal polynomials are found in the investigations of continued fractions by Stieltjes and Chebyshev. As the offspring grew, it soon went its separate way, developed an independent identity and all but forgot its roots. Recent years have seen a reconciliation of sorts as workers in orthogonal polynomials have rediscovered continued fractions and what they can do for the study of orthogonal polynomials and simultaneously, researchers in continued fractions have found new applications and generalizations involving orthogonal functions. Much of the credit for this renewal goes to the Colorado school of continued fractions and its Norwegian connection. The volume under review, containing the proceedings of a seminar-workshop held in Leon, Norway, reflects this fact, since the participants heavily represent the original members of this group and several generations of their students.

The longest of the sixteen papers in this volume, "Orthogonal Laurent polynomials on the real line," by Lyle Cochran and S. Clement Cooper, presents a comprehensive, self-contained survey of the title topic, which was first introduced by Jones, Thron and Waadeland in 1980. This summary should prove to be a useful introduction to this significant generalization of the classical moment problems and orthogonal polynomials. By contrast, a second fairly