ChE book review

Numerical Computation in Science and Engineering

by C. Pozrikidis

Published by Oxford University Press, Inc., 198 Madison Avenue, New York, NY 10016; 627 pages including index, $75.00 (1998)

Reviewed by
James N. Petersen
Washington State University

The necessity of obtaining numerical solutions to physical problems crosses virtually all the discipline boundaries in engineering and science. Only a limited number of books are available, however, that provide the fundamentals of scientific numerical computational techniques, together with application of those techniques. In general, Pozrikidis has been able to achieve this result in his book, which is intended to be used in upper-level undergraduate and beginning graduate courses and may be suitable for individual study. In so doing, he has produced a book that strikes a balance between rigor and practicality.

While not providing lengthy computer codes in the text, he has communicated the essential aspects of various numerical methods by relying on code fragments and pseudoCode that can be translated into any suitable computer language. In so doing, he has covered most of the topics required in an introductory course within a manageable number of pages. To compliment the text, he has also provided access, via the Internet, to a public domain software library of Fortran 77 programs, organized by book chapter.

The book is organized into eleven chapters. Each of them is further divided into sections and subsections. Because the subsections are the intended functional learning entities, the author provides both theoretical and computational problems at the end of each. These problems are designed to complement the theory presented and to provide the student with an immediate opportunity to practice its implementation.

The chapters are organized in a fashion similar to many other numerical methods books. In Chapter 1, the author provides a background of computer hardware, computer arithmetic including both integer and floating-point representations, and errors. In the next three chapters, he first lays a foundation on which to build the solution of linear and nonlinear sets of simultaneous equations. Thus, in Chapter 2 he covers matrix algebra and matrix calculus, and Chapter 3 is devoted to the solution of sets of linear algebraic equations. The solutions of sets of simultaneous nonlinear algebraic equations is discussed in Chapter 4, and he goes on to discuss eigenvalues of matrices in Chapter 5.

Continued on page 65.

avoiding, for the most part, the complexities introduced by transform mathematics. Finally, we realize that students completing this course will not be experts in DLQR design methods. They will, however, have had a practical introduction to the topic that will alert them to the power and potential of advanced control techniques. They will also be aware of some of the relationships among three control methods representative of the electro-mechanical, process, and traditional control communities, *i.e.*, DLQR, MPC, and PID.

The final important aspect of the course is the laboratories and their integration with the lecture material. In a sense, the course is driven by the laboratory experiments and the students are motivated to master the lecture material so that they can perform the laboratory experiments satisfactorily. Homework assignments are carefully chosen so that satisfactory completion of the last assignment before a lab should fully prepare the student to carry out the experiment properly.

PLANS FOR FUTURE DEVELOPMENT

A number of plans are underway for further development of the course. New laboratory experiments are always under consideration. We plan to include an experiment involving system identification to develop an empirical model of the headbox process next year. Longer-range plans include adding a third input and a third output to the headbox experiment and developing a new experiment using a distillation column as the process to be controlled. The lecture material is also being continually refined and updated to find more logical and consistent ways to introduce this relatively advanced material to students at this stage in their development. More emphasis will be given to IMC methods such as MPC and DMC in future versions of the course. The course notes currently being used as the course text are being readied for publication and should be submitted to a publisher this year.

ACKNOWLEDGMENT

The authors are very grateful to Barry King for constructing and maintaining the laboratory experiments and for his assistance with the students in the laboratory.

REFERENCES

1. *Matlab: High Performance Numeric Computation and Visualization Software,* The Mathworks, Inc., Natick, MA (1993)
2. Garcia, C.E., D.M. Prett, and M. Morari, "Model Predictive Control: Theory and Practice, A Survey," *Automatica,* **25**, 335 (1989)
3. Morari, M., and E. Zafiriou, *Robust Process Control,* PTR Prentice Hall, Englewood Cliffs, NJ (1989)
4. Kuo, B.C., *Digital Control Systems,* Holt, Rinehart, and Winston, Inc., New York, NY (1980)
5. Zhou, K., J.C. Doyle, and K. Glover, *Robust and Optimal Control,* Prentice Hall, Upper Saddle River, NJ (1996)
6. Ramirez, W.F., *Process Identification and Control,* Academic Press, Boston, MA (1994)
7. Franklin, G.F., J.D. Powell, and A. Emami-Naeini, *Feedback Control of Dynamic Systems,* Addison-Wesley, Reading, MA (1994)
8. *Simulink: Dynamic System Simulation Software,* The Mathworks, Inc., Natick, MA (1993)
9. *Control Systems Toolbox,* The Mathworks, Inc., Natick, MA (1993)
10. Kwakernaak, H. and R. Sivan, *Linear Optimal Control Systems,* Wiley-Interscience, New York, NY (1972). ❒

BOOK REVIEW: Numeric Computation

Continued from page 11.

The next three chapters are devoted to function interpolation and differentiation (Chapter 6), numerical integration (Chapter 7), and approximation of functions, lines, and surfaces (Chapter 8). In the final chapters, the author discusses the solution of ordinary differential equations and initial value problems (Chapter 9), boundary-value, eigenvalue, and free-boundary problems (Chapter 10), and finite-difference methods for partial differential equations (Chapter 11).

Finally, the author provides four appendices. In Appendix A, he provides a brief calculus refresher, with a table of various series approximations to a variety of functions. In Appendix B, he discusses orthogonal polynomials. Again, he includes a number of tables of various orthogonal polynomials, including Legendre, Chebyshev, Jacobi, Radau, Lobatto Laguerre, Hermite, and Gram, and their properties.

Developing the ability to proficiently use the computer and interface with the operating system is one of the main hurdles often encountered by students in a numerical methods course. Appendix C provides this essential background information, including an introduction to the c-shell, to the unix file system, to the vi editor, and to the compilation and linking of typical programs. Finally, Appendix D provides a Fortran primer, while an index to the publicly available programs discussed above is provided in Appendix E.

Although they are covered briefly in Chapter 10, I would have liked additional coverage of weighted residual techniques. These methods provide a powerful tool for the solution of ordinary differential equations and provide the basis of finite element methods for the solution of partial differential equations. In devoting only seventeen pages to this topic, the author has given the students only a brief glimpse of the power of such methods and may leave students thinking that they are not as useful as others that are covered in much more detail. Further, as is often the case, the coverage of techniques for solving partial differential equations is quite limited. I assume that this is because the author expects this materials to be covered in a later course.

In general, Pozrikidis has met his goals and has produced a usable text in which he covers the fundamentals of numerical methods, while at the same time enabling the reader to understand how to use the various techniques to solve physical problems in science and engineering. ❒