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Text Teaches Fundamental Numerical Analysis For Engineers

Reviewed by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Approximation Techniques for Engineers, Second Edition, Louis Komzsik, CRC Press, Taylor & Francis Group, 2017, 366 pages, glossy hardback, ISBN-13: 978-1-138-70005-5.

The approximation techniques covered in this book are otherwise referred to as numerical methods, part of the branch of mathematics called *numerical analysis*. The author has a Ph.D. obtained in Budapest, Hungary, where he graduated from both the Technical University and the Eötvös U. of Sciences. In America, he has worked as a senior analyst for McDonnell-Douglas and as chief numerical analyst for MSC Software, retiring recently from Siemens PLM Software as principle key CAE expert. The book reflects this background in that it is presented in a way that can appeal to engineers more than some numerical analysis books written by career mathematicians.

As for the contents, it is divided into two parts; first, the "Data Approximations" methods, which consist of fitting functions to data points with various splines and least-square fits. The section opens, however, with more basic interpolators of Newton, Lagrange, and Hermite. Digital signal processing (DSP) in µC-based systems nowadays, such as data-acquisition systems (DASs) and precision DVMs, will most often use Chebyschev function approximation for minimizing (or at least controlling) error bounds of the approximating function.

Chebyshev data-point approximation does not appear in this book—perhaps to the relief of some readers—because it takes more effort to implement than the reviewer's favorite, the Lagrange interpolator, which can be used to construct the Lagrange interpolating function directly from selected data points. And it works in either direction, as a function or its inverse. This is particularly helpful when implementing, for instance, a nonlinear temperature or pressure channel on a DAS. In the forward direction, it corrects or linearizes sensor acquisition points, and in the inverse direction, it can be used to calibrate the channel by finding the values of the calibration parameters. The same algorithm is used for both by swapping the x and y values.

With a large number of data points, the three basic methods, which result in polynomials of the same degree as the number of points, can undulate unduly from the high-degree terms. Splines involve a set of methods based on using a low-degree polynomial such as a cubic, and interpolating the overall function by using multiple piecewise functions (which are the splines) over a set of intervals, with one spline function per interval, including endpoint fitting. This can be accomplished in multiple ways and this section covers them, such as Bezier splines, familiar to anyone who has used a computer drawing program.

The book then moves on to chapter 4 and function approximation. When an analytic (continuous) function is given, how can it be approximated more simply, to reduce computation? Methods covered are those of Legendre, Chebyshev, Fourier, and Padé. They generally result in a power-series expansion of an orthogonal set of functions, each with coefficients.

Throughout the book the author assumes that the reader has some grasp of matrix math—that you know what a positive-definite matrix is and Gram-Schmidt orthogonalization of matrices. If you are weak on matrix math (as I am), do not let this distance you too far from the book because most of the matrix math in it is simple and what is unfamiliar is explained to some extent (such as the Gram-Schmidt procedure). The Fourier series approximation is familiar to electrical engineers; the Padé approximation is less familiar but is a quite useful method for approximating rational functions such as s-domain transfer functions.

The last two chapters of the first section are about numerical differentiation and integration, topics of great importance to electronics engineers. Where these methods are commonly encountered are in µC-based systems with sampled feedback loops. Sampling turns continuous (analog) waveforms into discrete ones consisting of discrete sample points of a waveform. If the waveform is to be integrated in the µC, how is it best accomplished with only discrete points? This is a DSP problem, and DSP is just another name for numerical analysis, applied to electronics.

As an aside, there are three different areas of knowledge that have the same underlying theory: numerical analysis (math), DSP and sampling-circuits theory (software and electronics engineering), and discrete control theory (also engineering). Each uses somewhat different terminology, but if you learn one well, it is not hard to discover that you almost know the others too.

Integration is usually a more important topic than differentiation, and its chapter begins with familiar, simple schemes such as two-point trapezoidal integration and (three-point) Simpson's Rule. It then advances from there to include Chebyshev integration, which is important for DAS and DVM applications, and for digital filters.

The second and last section of the book is about finding approximate solutions to equations, beginning with nonlinear equations of one variable. The section starts with the simple and familiar binary chop ("method of bisection"), which is similar to successive approximation in electronics, then the secant method which is highly useful and often quite adequate.

The next chapter is about solving systems of nonlinear equations, Newton's method (which can also be used to solve single-variable equations) and related methods such as "steepest descent". A chapter (9) on the iterative solution of linear equations is matrix intensive. Eigenvalue problems are then taken on. "Eigenvalues" in an electronic circuit context are circuit poles. The math is all matrix math. These last two chapters are useful as preparatory background to anyone who wants to learn the matrix methods used in modern control theory.

Chapter 11 is on "Initial value problems" which mean solving ordinary differential equations. Names of methods such as Euler, Taylor, and Runge-Kutta appear. It is good to know the Runge-Kutta method because it is used extensively in electronics, such as in circuit simulators. Then there are predictor-corrector methods, Picard's successive approximation, and some explanation of model order reduction.

Chapter 12 is about solving multidimensional, partial differential equations as "Boundary value problems". This is where finite difference and finite element methods appear. Chapter 13 is on "Integral equations", where you will learn the difference between a Fredholm (definite integral) and a Volterra (only one limit of integration a fixed constant) type of integral equation, of the first or second kind, homogeneous or not, and linear or nonlinear.

The last chapter (14) is on "Mathematical optimization". Starting with finding extrema in calculus, the topic is expanded to multivariate functions. Gradient-based methods are featured, then some methods more applicable to mechanical and structural engineering than electrical end the book, with one page of closing remarks. Following this is a list of figures, of tables, annotation, and a four-page index.

Because numerical analysis is one of my favorite topics in math (or is it engineering?), I have several books on the topic. Among them, this book scores about average, though it is up against some heavyweight Dover titles by Hildebrand and Hamming. There are easier books to read, and this book does not annoy the engineer who is already familiar with the subject with unnecessary, detailed explanation.

Yet for the electronics engineer who wants to better understand numerical analysis, this book is a good fit, especially if you want to improve your matrix math ability. It has an intermediate amount of detail and the most important methods that will be found and used in power electronics, and for this reason, it can be a good book to acquire.

About The Author

Dennis Feucht has been involved in power electronics for over 30 years, designing motor-drives and power converters. He has an instrument background from Tektronix, where he designed test and measurement equipment and did research in Tek Labs. He has lately been working on projects in theoretical magnetics and power converter research.

To read Dennis' reviews of other texts on power supply design, magnetics design and related topics, see How2Power's Power Electronics Book Reviews.