Inverse Problems **18** (February 2002) 283-284

BOOK REVIEW

The Mathematics of Computerized Tomography (Classics in Applied Mathematics, Vol. 32)

Frank Natterer
Philadelphia, PA: SIAM 2001
xviii+222 pp $61.00 (softcover)
(First published by Teubner, Stuttgart and Wiley, Chichester in 1986)
ISBN: 0-89871-493-1

Sixty-two years passed between the publication of Radon's inversion formula in the *Berichte Sächsische Akademie der Wissenschaften* in Leipzig in 1917 and the 1979 Nobel prize in medicine awarded to Allen M Cormack and Godfrey N Hounsfield for their pioneering contributions to the development of computerized tomography (CT). The field of computerized tomography has since then witnessed progress and development which can be encapsulated in no other words than scientific explosion. Transmission, emission, ultrasound, optical, electrical impedance and magnetic resonance are all CT imaging modalities based on different physical models. But not only diagnostic radiology has been revolutionized by CT, many other scientific and technological areas from non-destructive material testing to seismic imaging in geophysics and from electron microscopy for biological studies to radiation therapy treatment planning have all been transformed and seen new paths being broken by the introduction of the principles of CT.

The mathematical formulation of CT commonly leads to an *inverse problem* putting the underlying physical phenomenon and its model at the mercy of mathematics and mathematical techniques. Inadequate modelling due to insufficient understanding of the physics or due to practical limitations which result in incomplete data collection make the mathematical inversion difficult, and sometimes impossible. Two fundamentally different approaches are available. One way is to use `continuous' modelling in which quantities are represented by functions and their relations by operators between function spaces. In this approach the inversion problem at hand is solved and then the solution formula(e) are discretized for computational implementation. Another route is to first fully discretize the problem at the modelling stage and represent quantities by finite-dimensional vectors and the relations between them by functions over the vector space. Then a solution of the fully discretized inverse problem is reached which does not need further discretization of formulae for the computer implementation.

Natterer's book handles the mathematics of CT in the `continuous' approach. In the preface to the original 1986 book the author wrote: `In this book I have made an attempt to collect some mathematics which is of possible interest both to the research mathematician who wants to understand the theory and algorithms of CT and to the practitioner who wants to apply CT in his special field of interest'. This attempt, one must say, was indeed very successful. In spite of the further tremendous progress that occurred since the original book appeared, the book is still a treasure for anyone joining or already working in the field. This proves that the choice of topics and the organization of material were very well done and are still useful and relevant. After a brief introduction (Chapter I), the book treats the following topics: the Radon transform and related transforms (Chapter II), sampling and resolution (Chapter III), ill-posedness and accuracy (Chapter IV), reconstruction algorithms (Chapter V), incomplete data (Chapter VI) and, finally, an appendix of mathematical tolls (Chapter VII). Except for the addition of a table of errata, the book is an unabridged republication of the original book. Therefore, it is the reader's responsibility to bridge the knowledge and literature gaps from 1986 until today with the aid of other sources. Nonetheless this book is an excellent starting point for such a journey into the mathematics of computerized tomography, together with some other books from that period that withstood the `teeth of time' such as those of Herman (New York: Academic Press 1980) and of Kak and Slaney (Piscataway, NJ: IEEE Press 1988) (see also: *Classics in Applied Mathematics, Vol. 33* (Philadelphia, PA: SIAM)).

Yet another interesting facet of the development of the field of CT was, and still is, the continuous stream of mathematical problems it generates. Some mathematical problems aim at reaching practical solutions for either a `continuous' model or a fully discretized model of the ever newly emerging real-world CT problems. Others are more theoretical extensions to integral geometry, such as reconstruction from integrals over arbitrary manifolds, and to a variety of other fields in pure mathematics (see, e.g., Grinberg E and Quinto E T (ed) 1990 *Integral Geometry and Tomography* (Providence, RI: American Mathematical Society)). Natterer's book, although admittedly not handling such extensions, is an indispensable tool for anyone planning to direct his efforts in those directions.

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Mathematics of thermoacoustic tomography - Volume 19 Issue 2 - PETER KUCHMENT, LEONID KUNYANSKY.Â Analysis, geometry, number theory: The mathematics of Leon Ehrenpreis In: Contemp. Math. 251, AMS, Providence, RI, pp. 1â€“14.Â [62]Herman, G. (editor) (1979) Topics in Applied Physics, Vol. 32: Image Reconstruction from Projections Springer-Verlag, Berlin. [63]HÃ¶rmander, L. (1983) The Analysis of Linear Partial Differential Operators, Vol. 1, Springer-Verlag, New York.Â [67]Kak, A. C. & Slaney, M. (2001) Principles of Computerized Tomographic Imaging, SIAM, Philadelphia, PA. [68]KÃ¶stli, K. P.Frenz, M.Bebie, H. & Weber, H. P. (2001) Temporal backward projection of optoacoustic pressure transients using Fourier transform methods. Phys.