BOOK REVIEW

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

Frank Natterer
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),
il-posedness and accuracy (Chapter IV), reconstruction algorithms (Chapter V),
incomplete data (Chapter VI) and, finally, an appendix of mathematical tools (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:
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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By computerized tomography (CT) we mean the reconstruction of a function from its line or plane integrals, irrespective of the field where this technique is applied. In the early 1970s CT was introduced in diagnostic radiology and since then, many other applications of CT have become known, some of them preceding the application in radiology by many years. 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.