

# Contents

<i>Preface</i>	ix
<b>1 Introduction</b>	<b>1</b>
References	3
<b>2 Signal Processing Fundamentals</b>	<b>5</b>
2.1 One-Dimensional Signal Processing	5
Continuous and Discrete One-Dimensional Functions • Linear Operations • Fourier Representation • Discrete Fourier Transform (DFT) • Finite Fourier Transform • Just How Much Data Is Needed? • Interpretation of the FFT Output • How to Increase the Display Resolution in the Frequency Domain • How to Deal with Data Defined for Negative Time • How to Increase Frequency Domain Display Resolution of Signals Defined for Negative Time • Data Truncation Effects	
2.2 Image Processing	28
Point Sources and Delta Functions • Linear Shift Invariant Operations • Fourier Analysis • Properties of Fourier Transforms • The Two-Dimensional Finite Fourier Transform • Numerical Implementation of the Two-Dimensional FFT	
2.3 References	47
<b>3 Algorithms for Reconstruction with Nondiffracting Sources</b>	<b>49</b>
3.1 Line Integrals and Projections	49
3.2 The Fourier Slice Theorem	56
3.3 Reconstruction Algorithms for Parallel Projections	60
The Idea • Theory • Computer Implementation of the Algorithm	
3.4 Reconstruction from Fan Projections	75
Equiangular Rays • Equally Spaced Collinear Detectors • A Re-sorting Algorithm	
3.5 Fan Beam Reconstruction from a Limited Number of Views	93
3.6 Three-Dimensional Reconstructions	99
Three-Dimensional Projections • Three-Dimensional Filtered Backprojection	

3.7	Bibliographic Notes	107	
3.8	References	110	
4	<i>Measurement of Projection Data—The Nondiffracting Case</i>		113
4.1	X-Ray Tomography	114	
	Monochromatic X-Ray Projections • Measurement of Projection Data with Polychromatic Sources • Polychromaticity Artifacts in X-Ray CT • Scatter • Different Methods for Scanning • Applications		
4.2	Emission Computed Tomography	134	
	Single Photon Emission Tomography • Attenuation Compensation for Single Photon Emission CT • Positron Emission Tomography • Attenuation Compensation for Positron Tomography		
4.3	Ultrasonic Computed Tomography	147	
	Fundamental Considerations • Ultrasonic Refractive Index Tomography • Ultrasonic Attenuation Tomography • Applications		
4.4	Magnetic Resonance Imaging	158	
4.5	Bibliographic Notes	168	
4.6	References	169	
5	<i>Aliasing Artifacts and Noise in CT Images</i>		177
5.1	Aliasing Artifacts	177	
	What Does Aliasing Look Like? • Sampling in a Real System		
5.2	Noise in Reconstructed Images	190	
	The Continuous Case • The Discrete Case		
5.3	Bibliographic Notes	200	
5.4	References	200	
6	<i>Tomographic Imaging with Diffracting Sources</i>		203
6.1	Diffracted Projections	204	
	Homogeneous Wave Equation • Inhomogeneous Wave Equation		
6.2	Approximations to the Wave Equation	211	
	The First Born Approximation • The First Rytov Approximation		
6.3	The Fourier Diffraction Theorem	218	
	Decomposing the Green's Function • Fourier Transform Approach • Short Wavelength Limit of the Fourier Diffraction Theorem • The Data Collection Process		
6.4	Interpolation and a Filtered Backpropagation Algorithm for Diffracting Sources	234	
	Frequency Domain Interpolation • Backpropagation Algorithms		

6.5	Limitations	247	
	Mathematical Limitations • Evaluation of the Born Approximation • Evaluation of the Rytov Approximation • Comparison of the Born and Rytov Approximations		
6.6	Evaluation of Reconstruction Algorithms	252	
6.7	Experimental Limitations	261	
	Evanescent Waves • Sampling the Received Wave • The Effects of a Finite Receiver Length • Evaluation of the Experimental Effects • Optimization • Limited Views		
6.8	Bibliographic Notes	268	
6.9	References	270	
7	<i>Algebraic Reconstruction Algorithms</i>		275
7.1	Image and Projection Representation	276	
7.2	ART (Algebraic Reconstruction Techniques)	283	
7.3	SIRT (Simultaneous Iterative Reconstructive Technique)	284	
7.4	SART (Simultaneous Algebraic Reconstruction Technique)	285	
	Modeling the Forward Projection Process • Implementation of the Reconstruction Algorithm		
7.5	Bibliographic Notes	292	
7.6	References	295	
8	<i>Reflection Tomography</i>		297
8.1	Introduction	297	
8.2	B-Scan Imaging	298	
8.3	Reflection Tomography	303	
	Plane Wave Reflection Transducers • Reflection Tomography vs. Diffraction Tomography • Reflection Tomography Limits		
8.4	Reflection Tomography with Point Transmitter/Receivers	313	
	Reconstruction Algorithms • Experimental Results		
8.5	Bibliographic Notes	321	
8.6	References	321	
	<i>Index</i>		323
	<i>About the Authors</i>		329