
Contents

1	Introduction	1
1.1	Signals and Signal Processing	1
1.2	Local Analysis	2
1.2.1	Transforms	2
1.2.2	Fourier Transform	3
1.2.3	Short Time Fourier Transform (STFT)	4
1.2.4	Wavelet Transform	4
1.2.5	Visualization	7
1.2.6	Fourier vs. Wavelet Transform - A Comparison Experiment	9
1.3	A Roadmap for the Book	11
2	Continuous Analysis	13
2.1	The Short Time Fourier Transform (STFT)	14
2.1.1	Definition, Computation and Reconstruction	14
2.1.2	Phase Space and Localization Parameters	18
2.1.3	Implementation with MATLAB and Visualization	19
2.2	The Continuous Wavelet Transform (CWT)	21
2.2.1	Definition, Computation and Reconstruction	21
2.2.2	Wavelet Examples	26
2.2.3	Implementation with MATLAB and Visualization	29
2.2.4	Application: Detection of Signal Changes	32
2.3	Case Studies	33
2.3.1	Analysis of Sensor Signals	33
2.3.2	Analysis and Classification of Audio Signals	36
2.4	Notes and Exercises	40
3	The Discrete Wavelet Transform	43
3.1	Redundancy of the CWT and the STFT	43
3.2	The Haar-System	45
3.2.1	Continuous-Time Functions	46

3.2.2	Sequences	49
3.3	Generalization to Daubechies-Wavelets	53
3.3.1	From Filters to Functions	56
3.3.2	Transfer Properties	59
3.4	Multiscale Analysis	60
3.4.1	One-Dimensional Signals	61
3.4.2	Two-Dimensional Signals (Images).....	65
3.4.3	Implementations with the MATLAB Wavelet Toolbox..	69
3.4.4	Generalization: Biorthogonal Filters	73
3.5	A Unifying Viewpoint: Basis Systems	75
3.5.1	One-Dimensional Signals	76
3.5.2	Two-Dimensional Signals	79
3.5.3	Computation and Visualization with MATLAB	81
3.6	Case Studies	81
3.6.1	Energy Compaction and Compression	81
3.6.2	Denosing a Sensor Signal / Real-Time Properties of the Algorithm.....	88
3.7	Notes and Exercises	91
4	More Applications	95
4.1	The Transform Compression Scheme	95
4.1.1	The General Procedure	97
4.1.2	Entropy Coders	99
4.1.3	Optimal Quantization and Examples.....	108
4.1.4	MATLAB Implementation	113
4.2	Wavelet-Based Similarity Retrieval in Image Archives	116
4.3	Notes and Exercises	123
5	Appendix	125
5.1	Fourier Transform and Uncertainty Relation	125
5.2	Discrete Fourier Transform (DFT)	128
5.3	Digital Filters	130
5.4	Solutions to Selected Problems	134
5.4.1	Problems from Sect. 2.4	134
5.4.2	Problems from Sect. 3.7	138
5.4.3	Problems from Sect. 4.3	142
5.5	Notations and Symbols.....	146
	References	147
	Index	149