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
X  Contents

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 Denoising 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
Wavelets and Signal Processing
An Application-Based Introduction
Stark, H.-G.
2005, X, 150 p. 67 illus., Hardcover
ISBN: 978-3-540-23433-3