

Contents

Foreword	ix
Notations and Abbreviations	xi
Chapter 1 Recap on Digital Signal Processing	1
1.1 The sampling theorem	2
1.2 Spectral contents	7
1.2.1 Discrete-time Fourier transform (DTFT)	7
1.2.2 Discrete Fourier transform (DFT)	8
1.3 Case of random signals	10
1.4 Example of the Dual Tone Multi-Frequency (DTMF)	11
Chapter 2 Additional Information About Filtering	15
2.1 Filter implementation	15
2.1.1 Examples of filter structures	16
2.1.2 Distributing the calculation load in an FIR filter	20
2.1.3 FIR block filtering	21
2.1.4 FFT filtering	23
2.2 Filter banks	29
2.2.1 Decimation and expansion	30
2.2.2 Filter banks	34
2.3 Ripple control	42
2.3.1 Principle	42
2.3.2 Programming	44
Chapter 3 Image Processing	51
3.1 A little geometry	51
3.1.1 3D object	51
3.1.2 Calibration of cameras	53
3.2 Pyramidal decompositions	62
3.2.1 Pyramidal decomposition given by Burt and Adelson	64

3.2.2	Pyramidal decomposition using a Haar transformation	65
3.2.3	Stepwise decomposition (<i>lifting scheme</i>)	66
Chapter 4	Numerical Calculus and Simulation	71
4.1	Simulation of continuous-time systems	71
4.1.1	Simulation by approximation	71
4.1.2	Exact model simulation	72
4.2	Solving of ordinary differential equations (ODEs)	76
4.2.1	Conversion from continuous to discrete time	76
4.2.2	Linear case, continuous-time solution	78
4.2.3	Remarks on the Runge–Kutta methods	81
4.3	Systems of equations and zero-seeking	88
4.3.1	Zeros of a function using the Newton method	88
4.3.2	Roots of a polynomial with the Newton–Raphson method	89
4.3.3	Systems of nonlinear equations	90
4.4	Interpolation	91
4.4.1	Thiele’s interpolation	92
4.4.2	Another decomposition in continuous fractions	95
4.4.3	Natural cubic splines	96
4.5	Solving of linear systems	100
4.5.1	Jacobi method	100
4.5.2	Relaxation method	101
4.5.3	Cholesky factorization	102
Chapter 5	Speech Processing	105
5.1	A speech signal model	105
5.1.1	Overview	105
5.1.2	A typology of vocal sounds	106
5.1.3	The AR model of speech production	107
5.1.4	Compressing a speech signal	113
5.2	Dynamic Time Warping	116
5.2.1	The DTW algorithm	117
5.2.2	Examples of pathfinding rules	118
5.2.3	Cepstral coefficients	119
5.3	Modifying the duration of an audio signal	120
5.3.1	PSOLA	121
5.3.2	Phase vocoder	123
5.4	Eliminating the impulse noise	124
5.4.1	The signal model	125
5.4.2	Click detection	126
5.4.3	Restoration	128

Chapter 6 Selected Topics	131
6.1 Tracking the cardiac rhythm of the fetus	131
6.1.1 Objectives	131
6.1.2 Separating the EKG signals	132
6.1.3 Estimating cardiac rhythms	136
6.2 Extracting the contour of a coin	142
6.3 Constrained optimization and Lagrange multipliers	146
6.3.1 Equality-constrained optimization	146
6.3.2 Quadratic problem with linear inequality constraints . .	149
6.3.3 Portfolio optimization	153
6.4 Principal Component Analysis (PCA)	163
6.4.1 Determining the principal components	164
6.4.2 2-Dimension PCA	168
6.4.3 Linear Discriminant Analysis	170
6.5 GPS positioning	175
6.6 The Viterbi algorithm	178
6.6.1 Convolutional non-recursive encoder	179
6.6.2 Decoding and hard decision	181
Chapter 7 Hints and Solutions	187
H1 Reminders on digital signal-processing	187
H2 Additional information on filtering	189
H3 Image Processing	194
H4 Numerical calculus	197
H5 Speech processing	215
H6 Selected topics	231
Chapter 8 Appendix	243
A1 A few properties of a matrix	243
A2 A few relations for matrices	246
Bibliography	247
Index	251