

Contents

1 Non-Biological Signals	1
1.1 Notation	2
1.2 Discrete- and Continuous-Time Determinist Signals	2
1.2.1 Sampling Theorem	4
1.2.2 Upsampling	9
1.2.3 Downsampling and Decimation	12
1.2.4 Anti-Aliasing Filter (AAF)	12
1.2.5 Quantization	14
1.2.6 Delta Modulation (DM)	17
1.2.7 Sigma-Delta ($\Sigma - \Delta$) Modulation	20
1.3 Discrete- and Continuous-Time Random Signals	23
1.3.1 Stationarity	28
1.3.2 Monte Carlo Simulation	34
1.3.3 Energy and Power	46
1.3.4 Ergodicity	49
1.3.5 Power Spectrum Density (PSD)	57
1.3.6 Signal Space Representation	69
1.3.7 Mean-Square Sense Sampling Theorem	82
2 Linear and Nonlinear Systems	87
2.1 Linear Systems Theory	87
2.1.1 System Function	89
2.1.2 Response of Linear Systems to Random Signals	91
2.2 Response of Nonlinear Systems to Random Signals	104
2.2.1 Nonlinear Processing of Gaussian Signals	105
2.2.2 Nonlinear Processing of WSS Gaussian Processes	113
2.2.3 Output PSD of DM Devices with WSS Gaussian Input	117
2.3 Systems with Signal + Noise	120
2.3.1 Signal-to-Noise Ratio (SNR)	124
2.3.2 Matched and Optimum Filtering	126

3	Biological Signals	137
3.1	Electrocardiogram (ECG)	138
3.1.1	QRS Complex	139
3.1.2	The P Wave	141
3.1.3	The PR Segment	141
3.1.4	The QRS Wave	141
3.1.5	The ST Segment	142
3.1.6	The T Wave	142
3.2	Electroencephalogram (EEG)	144
3.2.1	δ Band	169
3.2.2	θ Band	170
3.2.3	α Band	170
3.2.4	β Band	170
3.2.5	γ Band	170
3.2.6	EEG Signals	171
3.3	Electromyogram (EMG)	171
4	Signal Processing Methods for Biological Signals	175
4.1	Independence	176
4.1.1	Uncorrelated	176
4.1.2	Orthogonal	178
4.2	Is It Gaussian?	179
4.2.1	Kurtosis	179
4.2.2	Entropy and Negentropy	180
4.2.3	Mutual Information	183
4.3	“Distance” Between Two PDFs	186
4.3.1	Kolmogorov-Smirnov (KS) Distance	187
4.3.2	Hellinger Distance (HD)	187
4.3.3	Kullback-Leibler (KL) Divergence	188
4.4	Detection and Estimation Methods	200
4.4.1	Signal Detection Using Hypothesis Testing (HT)	200
4.4.2	Specificity and Sensitivity	208
4.4.3	Parameter Estimation	238
4.4.4	Whittle Likelihood Test (WLT)	252
4.4.5	Frequency Estimation	258
5	Signal Decomposition Methods	277
5.1	Principle Component Analysis	277
5.2	Independent Component Analysis	288
5.2.1	Infomax	291
5.3	Wavelet Decomposition (WD)	301
5.3.1	Short Term Fourier Transform (STFT)	302
5.3.2	Continuous WT (CWT)	314
5.3.3	Father Wavelet	326

5.3.4	Orthogonal Wavelet	326
5.3.5	Wavelet Series Expansion (WSE)	330
5.3.6	Discrete Wavelet Transform (DWT)	334
5.3.7	Efficient Realization of DWT.	341
5.3.8	Signal Synthesis Using DWT.	348
6	References and Concluding Remarks.	377
6.1	Signals, Systems (Linear), Digital Signal Processing	377
6.2	Random Signals, System Response to Random Signals, and Detection/Estimation Theory	378
6.3	Biological Signals.	379
6.4	Principle and Independent Component Analysis	379
6.5	Wavelet Transform	379
	References	380

Biological Signals Classification and Analysis

Kiasaleh, K.

2015, XI, 380 p. 231 illus., 222 illus. in color., Hardcover

ISBN: 978-3-642-54878-9