

Contents

Foreword	ix
Notations and Abbreviations	xiii
1 Mathematical Concepts	1
1.1 Basic concepts on probability	1
1.2 Conditional expectation	9
1.3 Projection theorem	10
1.4 Gaussianity	13
1.5 Random variable transformation	18
1.5.1 Change of variable formula	18
1.5.2 δ -method	19
1.6 Fundamental statistical theorems	21
1.7 Other important probability distributions	23
2 Statistical Inferences	25
2.1 Statistical model	25
2.2 Hypothesis tests	27
2.2.1 Simple hypotheses	28
2.2.2 Generalized Likelihood Ratio Test (GLRT)	33
2.2.3 χ^2 goodness of fit test	39
2.3 Statistical estimation	41
2.3.1 General principles	41
2.3.2 Least squares method	43
2.3.3 Least squares method: linear model	44
2.3.4 Method of moments	56
2.3.5 Maximum likelihood	59
2.3.6 Estimating a distribution	75
2.3.7 Bootstrap and others	79

3	Monte-Carlo Simulation	85
3.1	Fundamental theorems	85
3.2	Stating the problem	86
3.3	Generating random variables	88
3.3.1	The cumulative function inversion method	89
3.3.2	The variable transformation method	91
3.3.3	Acceptance-rejection method	93
3.3.4	Sequential methods	95
3.4	Variance reduction	99
3.4.1	Importance sampling	99
3.4.2	Stratification	103
3.4.3	Antithetic variates	106
4	Second Order Stationary Process	107
4.1	Statistics for empirical correlation	107
4.2	Linear prediction of WSS processes	111
4.2.1	Yule-Walker equations	111
4.2.2	Levinson-Durbin algorithm	115
4.2.3	Reflection coefficients and lattice filters	120
4.3	Non-parametric spectral estimation of WSS processes	124
4.3.1	Correlogram	125
4.3.2	Periodogram	125
4.3.3	Smoothed periodograms	128
4.3.4	Coherence	135
5	Inferences on HMM	139
5.1	Hidden Markov Models (HMM)	139
5.2	Inferences on HMM	142
5.3	Gaussian linear case: the Kalman filter	143
5.4	Discrete finite Markov case	152
5.4.1	Forward-backward formulas	153
5.4.2	Smoothing with one instant	155
5.4.3	Smoothing with two instants	156
5.4.4	HMM learning using the EM algorithm	156
5.4.5	The Viterbi algorithm	158
6	Selected Topics	163
6.1	High resolution methods	163
6.1.1	Estimating the fundamental of periodic signals: MUSIC	163
6.1.2	Introduction to array processing: MUSIC, ESPRIT	177
6.2	Digital Communications	186
6.2.1	Introduction	186
6.2.2	8-phase shift keying (PSK)	189
6.2.3	PAM modulation	191

6.2.4	Spectrum of a digital signal	193
6.2.5	The Nyquist criterion in digital communications	198
6.2.6	The eye pattern	204
6.2.7	PAM modulation on the Nyquist channel	205
6.3	Linear equalization and the Viterbi algorithm	211
6.3.1	Linear equalization	213
6.3.2	The soft decoding Viterbi algorithm	215
6.4	Compression	220
6.4.1	Scalar Quantization	220
6.4.2	Vector Quantization	222
7	Hints and Solutions	235
H1	Mathematical concepts	235
H2	Statistical inferences	237
H3	Monte-Carlo simulation	269
H4	Second order stationary process	277
H5	Inferences on HMM	283
H6	Selected Topics	300
8	Appendices	317
A1	Miscellaneous functions	317
A2	Statistical functions	318
A.2.1	Notable functions	318
A.2.2	Beta distribution	318
A.2.3	Student's distribution	318
A.2.4	Chi-squared distribution	323
A.2.5	Fisher's distribution	326
	Bibliography	329
	Index	333