

Contents

List of Abbreviations

xi

1. A Brief Introduction to the Topic

1.1	Two Tasks for the Auditory System	1
1.2	An Ill-Posed Problem	2
1.3	Dealing With Ill-Posed Problems	5
1.4	Spectral Representation and Source Priors	6
1.5	Top-Down Selective Filtering	8
1.6	Audiovisual Integration	11
1.7	How to Use This Book	12
1.8	Overview	15
1.9	Exercises	19
	Acknowledgment	21
	References	21

2. The Nature of Sound

2.1	Longitudinal Pressure Waves in a Medium	23
2.2	The Homogeneous Wave Equation	28
2.2.1	Example: Interference and Binaural Beats	31
2.3	Harmonic Sound Waves and Acoustic Impedance	34
2.4	Acoustic Energy, Intensity, Decibel	37
2.5	Reflection, Transmission, and Impedance Matching	38
2.6	Sound Spectrum, Fourier Series, and Bandwidth	42
2.7	Phase Velocity and Group Velocity	46
2.8	Exercises	47
	References	50

3. Linear Systems

3.1	Modeling Physical and Biological Systems	51
3.2	Linear Systems: The Impulse Response	56
3.3	Linear Systems: The Transfer Characteristic	62
3.4	Combining Linear Systems in Control Schemes	66
3.5	Examples	68
3.6	Linear Systems: The Laplace Transform	71

3.7	Correlation Functions and Gaussian White Noise	79
3.8	Exercises	81
	References	86
4.	Nonlinear Systems	
4.1	Nonlinear Systems Identification	87
4.2	Nonlinear Systems Analysis: The Volterra Series	91
4.3	Nonlinear Systems Analysis: The Wiener Series	93
4.4	Independent Calculation of Volterra Kernels	106
4.5	Exercises	110
	References	112
5.	The Cochlea	
5.1	Introduction: From Acoustic Input to Traveling Wave	113
5.2	Basic Physics Underlying Water Waves	118
5.3	The Linear Cochlear Model (Von Békésy and Zwislocki)	124
5.4	The Active, Nonlinear Cochlea: Role of Outer Hair Cells	134
5.5	Exercises	142
	References	145
6.	The Auditory Nerve	
6.1	Introduction: Tuning of Auditory Nerve Fibers	147
6.2	Reverse Correlation and the Gammatone Filter	148
6.3	Phase Locking	152
6.4	Rate-Level Tuning of the Auditory Nerve	156
6.5	Two-Tone Suppression	158
6.6	Modeling the Auditory Nerve	159
6.7	Multitone Responses of the Auditory Nerve	163
6.8	Exercises	168
	References	168
7.	Acoustic Localization Cues	
7.1	Introduction	171
7.2	Interaural Time Differences	173
	7.2.1 Jeffress' Delay-Line Model	176
	7.2.2 Modeling Coincidence Detection	179
	7.2.3 Timed Inhibition	180
	7.2.4 Timed Inhibition?	183
7.3	Interaural Level Differences	184
	7.3.1 ILD Encoding at the LSO	187
7.4	The Cone of Confusion	188
7.5	Spectral Pinna Cues	190
	7.5.1 Possible Neural Correlate for Spectral Cues	194
	7.5.2 Localization in Elevation: An Ill-Posed Problem	195
	7.5.3 Alternative Elevation Cues?	199

7.6	Distance Perception	201
7.6.1	The Free Far Field	201
7.6.2	The Free Near Field	202
7.6.3	Reverberant Environments	203
7.7	Exercises	205
	References	206
8.	Assessing Auditory Spatial Performance	
8.1	Introduction	209
8.2	Signal-Detection Theory	210
8.3	Detection, Lateralization, Discrimination, and Localization	218
8.4	Sound Localization: Prey Versus Predator	228
8.5	Sound Localization: Effects of Spectral Content, Duration, and Level	230
8.5.1	Binaural Spectral Weighting	236
8.6	Virtual Acoustics	240
8.7	Exercises	242
	References	243
9.	The Gaze-Orienting System	
9.1	Introduction	245
9.2	Saccadic Eye Movements	248
9.3	Saccadic Eye–Head Gaze Shifts	262
9.4	Auditory and Visual-Evoked Gaze Saccades	265
9.5	Exercises	269
	References	271
10.	The Midbrain Colliculus	
10.1	Introduction	273
10.2	A Multisensory Motor Map for Gaze Orienting	278
10.3	SC: A Vectorial Pulse Generator	285
10.4	IC: Putative Role in Spatial Hearing	296
10.5	Exercises	301
	References	303
11.	Coordinate Transformations	
11.1	Introduction	305
11.2	Gain Fields and Predictive Remapping	310
11.3	The Static Double-Step Paradigm	313
11.3.1	Eye–Head Coordination	315
11.4	Dynamic Double Step: Visual and Auditory	317
11.5	Spatial Hearing is Influenced by Eye- and Head Position	323
11.6	Limits to Updating?	325
11.7	Exercises	330
	References	330

12. Sound Localization Plasticity	
12.1 Introduction	333
12.2 Learning Binaural Cues	341
12.3 Learning Spectral Cues	345
12.4 Visual Factors in Learning	351
12.5 Limits to Plasticity?	356
12.6 Exercises	358
References	358
13. Multisensory Integration	
13.1 Introduction	361
13.2 Models	368
13.3 Bayesian Inference	371
13.4 AV Congruent	380
13.5 AV Incongruent	383
13.6 Audio-Vestibular Integration	387
13.7 Exercises	390
References	390
14. Impaired Hearing and Sound Localization	
14.1 Introduction	393
14.2 Restorative Hearing Technologies	397
14.3 Single-Sided Deafness	399
14.4 Unilateral Conductive Hearing Loss	404
14.5 Bimodal Hearing: CI-HA	407
14.6 Presbycusis: Sometimes Superior Performance?	409
References	411
Subject Index	413