# Contents

1 **Introduction** ......................................................... 1  
   1.1 Background and Context ........................................ 1  
   1.2 Microphone Array Signal Processing ............................ 2  
   1.3 Organization of the Book ........................................ 5  
   References ............................................................ 8  

2 **Theoretical Preliminaries of Acoustics** .......................... 11  
   2.1 Fundamentals of Acoustics ....................................... 11  
   2.2 Sound Field Representation Using Spherical Harmonic  
       Expansion .......................................................... 14  
   2.3 Sign Convention .................................................... 19  
   2.4 Sound Intensity .................................................... 20  
   2.5 Chapter Summary ................................................... 21  
   References ............................................................ 22  

3 **Spatial Sampling and Signal Transformation** ...................... 23  
   3.1 Time-Frequency Domain Processing ............................. 23  
   3.2 Complex Spherical Harmonic Domain Processing ............... 25  
   3.3 Real Spherical Harmonic Domain Processing .................... 27  
   3.4 Spatial Sampling .................................................. 29  
       3.4.1 Sampling Schemes ............................................. 32  
       3.4.2 Array Configurations ....................................... 33  
   3.5 Chapter Summary ................................................... 36  
   References ............................................................ 36  

4 **Spherical Array Acoustic Impulse Response Simulation** .......... 39  
   4.1 Allen and Berkley’s Image Method ............................... 40  
       4.1.1 Green’s Function ............................................. 40  
       4.1.2 Image Method ............................................... 41  
   4.2 SMIR Method in the Spherical Harmonic Domain .................. 42  
       4.2.1 Green’s Function ............................................. 43  
       4.2.2 Neumann Green’s Function ................................... 44
7 Signal-Dependent Array Processing .................................. 113
  7.1 Signal Model ...................................................... 113
  7.2 Performance Measures .......................................... 117
    7.2.1 Speech Distortion Index ................................. 117
    7.2.2 Noise Reduction Factor .................................. 118
    7.2.3 Array Gain ................................................ 119
    7.2.4 Mean Square Error ........................................ 119
  7.3 Signal-Dependent Beamformers ................................. 120
    7.3.1 Maximum SNR Filter ...................................... 120
    7.3.2 Wiener Filter ............................................. 121
    7.3.3 Minimum Variance Distortionless Response Filter ..... 122
    7.3.4 Parametric Wiener Filter ................................. 126
    7.3.5 Linearly Constrained Minimum Variance Filter ...... 127
    7.3.6 Generalized Sidelobe Canceller Structure ............. 129
  7.4 Relative Transfer Function Estimation ....................... 133
    7.4.1 Covariance Subtraction Method ......................... 134
    7.4.2 Generalized Eigenvector Method ......................... 134
    7.4.3 Temporal Averaging Method ............................. 135
  7.5 Chapter Summary ................................................ 137
References ............................................................ 137

8 Parametric Array Processing ....................................... 141
  8.1 Signal Model .................................................... 142
  8.2 Parameter Estimation .......................................... 144
  8.3 Sound Pressure Estimation .................................... 145
  8.4 Applications .................................................... 146
    8.4.1 Directional Filtering ................................... 147
    8.4.2 Dereverberation ......................................... 148
  8.5 Chapter Summary ................................................ 149
References ............................................................ 149

9 Informed Array Processing ......................................... 151
  9.1 Noise Reduction Using Narrowband DOA Estimates .......... 152
    9.1.1 Signal Models ............................................ 153
    9.1.2 Tradeoff Beamformer ..................................... 155
    9.1.3 Signal Statistics Estimation ............................ 156
    9.1.4 Desired Speech Presence Probability Estimation ..... 159
    9.1.5 Algorithm Summary ...................................... 162
    9.1.6 Results ................................................... 163
  9.2 Dereverberation Using Signal-to-Diffuse Ratio Estimates .. 169
    9.2.1 Problem Formulation ..................................... 170
    9.2.2 Informed Filter for Dereverberation ................... 173
Theory and Applications of Spherical Microphone Array Processing
Jarrett, D.P.; Habets, E.A.P.; Naylor, P.A.
2017, XVI, 187 p. 45 illus., 42 illus. in color., Hardcover
ISBN: 978-3-319-42209-1