Sound Capture and Processing
To my family: the time to write this book was taken from them
5.7.4.3 Spatial Filter in Side-lobe Canceller Scheme 247
5.7.4.4 Combination with LMS Adaptive Filter 248

5.8 Specific Algorithms for Small Microphone Arrays 250
5.8.1 Linear Beamforming Using the Directivity of the Microphones 251
5.8.2 Spatial Suppressor Using Microphone Directivity 254
5.8.2.1 Time-invariant Linear Beamformers 255
5.8.2.2 Feature Extraction and Statistical Models 256
5.8.2.3 Probability Estimation and Features Fusion 258
5.8.2.4 Estimation of Optimal Time-invariant Parameters 258

5.9 Summary 260
Bibliography 261

6 Sound Source Localization and Tracking with Microphone Arrays 263

6.1 Sound Source Localization 263
6.1.1 Goal of Sound Source Localization 263
6.1.2 Major Scenarios 264
6.1.3 Performance Limitations 266
6.1.4 How Humans and Animals Localize Sounds 266
6.1.5 Anatomy of a Sound Source Localizer 270
6.1.6 Evaluation of Sound Source Localizers 271

6.2 Sound Source Localization from a Single Frame 272
6.2.1 Methods Based on Time Delay Estimation 272
6.2.1.1 Time Delay Estimation for One Pair of Microphones 272
6.2.1.2 Combining the Pairs 278
6.2.2 Methods Based on Steered-response Power 280
6.2.2.1 Conventional Steered-response Power Algorithms 281
6.2.2.2 Weighted Steered-response Power Algorithm 281
6.2.2.3 Maximum-likelihood Algorithm 282
6.2.2.4 MUSIC Algorithm 282
6.2.2.5 Combining the Bins 284
6.2.2.6 Comparison of the Steered-response Power Algorithms 285
6.2.2.7 Particle Filters 286

6.3 Post-processing Algorithms 291
6.3.1 Purpose 291
6.3.2 Simple Clustering 294
6.3.2.1 Grouping the Measurements 294
6.3.2.2 Determining the Number of Cluster Candidates 294
6.3.2.3 Averaging the Measurements in Each Cluster Candidate 295
6.3.2.4 Reduction of the Potential Sound Sources 296
6.3.3 Localization and Tracking of Multiple Sound Sources 296
6.3.3.1 k-Means Clustering 297
6.3.3.2 Fuzzy C-means Clustering 298
6.3.3.3 Tracking the Dynamics 299

6.4 Practical Approaches and Tips 300
6.4.1 Increasing the Resolution of Time-delay Estimates 300
6.4.2 Practical Alternatives for Finding the Peaks 301