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SPRINGER TOPICS IN SIGNAL PROCESSING

Microphone Array Signal Processing

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Microphone Array Signal Processing Springer Topics In Signal Processing

Boaz Rafaely

Microphone Array Signal Processing Springer Topics In Signal Processing:

Microphone Array Signal Processing Jacob Benesty,Jingdong Chen,Yiteng Huang,2008-03-11 In the past few years we have written and edited several books in the area of acousticandspeechsignalprocessing Thereasonbehindthisendeavoristhat there were almost no books available in the literature when we rst started while there was and still is a real need to publish manuscripts summarizing the most useful ideas concepts results and state of the art algorithms in this important area of research According to all the feedback we have received so far we can say that we were right in doing this Recently several other researchers have followed us in this journey and have published interesting books with their own visions and perspectives The idea of writing a book on Microphone Array Signal Processing comes from discussions we have had with many colleagues and friends As a c sequence of these discussions we came up with the conclusion that again there is an urgent need for a monograph that carefully explains the theory and implementation of microphone arrays While there are many manuscripts on antenna arrays from a narrowband perspective narrowband signals and narrowband processing the literature is quite scarce when it comes to s sor arrays explained from a truly broadband perspective Many algorithms for speech applications were simply borrowed from narrowband antenna rays However a direct application of narrowband ideas to broadband speech processing may not be necessarily appropriate and can lead to many m understandings *Microphone Arrays* Michael Brandstein,Darren Ward,2013-04-17 The study and implementation of microphone arrays originated over 20 years ago Thanks to the research and experimental developments pursued to the present day the field has matured to the point that array based technology now has immediate applicability to a number of current systems and a vast potential for the improvement of existing products and the creation of future devices In putting this book together our goal was to provide for the first time a single complete reference on microphone arrays We invited the top re searchers in the field to contribute articles addressing their specific topic s of study The reception we received from our colleagues was quite enthusi astic and very encouraging There was the general consensus that a work of this kind was well overdue The results provided in this collection cover the current state of the art in microphone array research development and technological application This text is organized into four sections which roughly follow the major areas of microphone array research today Parts I and II are primarily the oretical in nature and emphasize the use of microphone arrays for speech enhancement and source localization respectively Part III presents a num ber of specific applications of array based technology Part IV addresses some open questions and explores the future of the field **Speech and Audio Signal Processing** Ben Gold,Nelson Morgan,Dan Ellis,2011-08-23 When Speech and Audio Signal Processing published in 1999 it stood out from its competition in its breadth of coverage and its accessible intutiont based style This book was aimed at individual students and engineers excited about the broad span of audio processing and curious to understand the available techniques Since then with the advent of the iPod in 2001 the field of digital audio and music has exploded leading to a much greater interest in the technical aspects of audio

processing This Second Edition will update and revise the original book to augment it with new material describing both the enabling technologies of digital music distribution most significantly the MP3 and a range of exciting new research areas in automatic music content processing such as automatic transcription music similarity etc that have emerged in the past five years driven by the digital music revolution New chapter topics include Psychoacoustic Audio Coding describing MP3 and related audio coding schemes based on psychoacoustic masking of quantization noise Music Transcription including automatically deriving notes beats and chords from music signals Music Information Retrieval primarily focusing on audio based genre classification artist style identification and similarity estimation Audio Source Separation including multi microphone beamforming blind source separation and the perception inspired techniques usually referred to as Computational Auditory Scene Analysis CASA Microphone Arrays Jacob Benesty,Gongping Huang,Jingdong Chen,Ningning Pan,2023-08-09 This book explains the motivation for using microphone arrays as opposed to using a single sensor for sound acquisition The book then goes on to summarize the most useful ideas concepts results and new algorithms therein The material presented in this work includes analysis of the advantages of using microphone arrays including dimensionality reduction to remove the redundancy while preserving the variability of the array signals using the principal component analysis PCA The authors also discuss benefits such as beamforming with low rank approximations fixed adaptive and robust distortionless beamforming differential beamforming and a new form of binaural beamforming that takes advantage of both beamforming and human binaural hearing properties to improve speech intelligibility The book makes the microphone array signal processing theory and applications available in a complete and self contained text The authors attempt to explain the main ideas in a clear and rigorous way so that the reader can easily capture the potentials opportunities challenges and limitations of microphone array signal processing This book is written for those who work on the topics of microphone arrays noise reduction speech enhancement speech communication and human machine speech interfaces Parametric Time-Frequency Domain Spatial Audio Ville Pulkki,Symeon Delikaris-Manias,Archontis Politis,2017-12-26 A comprehensive guide that addresses the theory and practice of spatial audio This book provides readers with the principles and best practices in spatial audio signal processing It describes how sound fields and their perceptual attributes are captured and analyzed within the time frequency domain how essential representation parameters are coded and how such signals are efficiently reproduced for practical applications The book is split into four parts starting with an overview of the fundamentals It then goes on to explain the reproduction of spatial sound before offering an examination of signal dependent spatial filtering The book finishes with coverage of both current and future applications and the direction that spatial audio research is heading in Parametric Time frequency Domain Spatial Audio focuses on applications in entertainment audio including music home cinema and gaming covering the capturing and reproduction of spatial sound as well as its generation transduction representation transmission and perception This book will teach readers the tools needed

for such processing and provides an overview to existing research It also shows recent up to date projects and commercial applications built on top of the systems Provides an in depth presentation of the principles past developments state of the art methods and future research directions of spatial audio technologies Includes contributions from leading researchers in the field Offers MATLAB codes with selected chapters An advanced book aimed at readers who are capable of digesting mathematical expressions about digital signal processing and sound field analysis Parametric Time frequency Domain Spatial Audio is best suited for researchers in academia and in the audio industry *Study and Design of Differential Microphone Arrays* Jacob Benesty,Chen Jingdong,2012-10-23 Microphone arrays have attracted a lot of interest over the last few decades since they have the potential to solve many important problems such as noise reduction speech enhancement source separation dereverberation spatial sound recording and source localization tracking to name a few However the design and implementation of microphone arrays with beamforming algorithms is not a trivial task when it comes to processing broadband signals such as speech Indeed in most sensor arrangements the beamformer output tends to have a frequency dependent response One exception perhaps is the family of differential microphone arrays DMAs who have the promise to form frequency independent responses Moreover they have the potential to attain high directional gains with small and compact apertures As a result this type of microphone arrays has drawn much research and development attention recently This book is intended to provide a systematic study of DMAs from a signal processing perspective The primary objective is to develop a rigorous but yet simple theory for the design implementation and performance analysis of DMAs The theory includes some signal processing techniques for the design of commonly used first order second order third order and also the general Nth order DMAs For each order particular examples are given on how to form standard directional patterns such as the dipole cardioid supercardioid hypercardioid subcardioid and quadrupole The study demonstrates the performance of the different order DMAs in terms of beampattern directivity factor white noise gain and gain for point sources The inherent relationship between differential processing and adaptive beamforming is discussed which provides a better understanding of DMAs and why they can achieve high directional gain Finally we show how to design DMAs that can be robust against white noise amplification Theory and Applications of Spherical Microphone Array Processing Daniel P. Jarrett,Emanuël A.P. Habets,Patrick A. Naylor,2016-08-26 This book presents the signal processing algorithms that have been developed to process the signals acquired by a spherical microphone array Spherical microphone arrays can be used to capture the sound field in three dimensions and have received significant interest from researchers and audio engineers Algorithms for spherical array processing are different to corresponding algorithms already known in the literature of linear and planar arrays because the spherical geometry can be exploited to great beneficial effect The authors aim to advance the field of spherical array processing by helping those new to the field to study it efficiently and from a single source as well as by offering a way for more experienced researchers and engineers to consolidate their understanding adding either or both of

breadth and depth The level of the presentation corresponds to graduate studies at MSc and PhD level This book begins with a presentation of some of the essential mathematical and physical theory relevant to spherical microphone arrays and of an acoustic impulse response simulation method which can be used to comprehensively evaluate spherical array processing algorithms in reverberant environments The chapter on acoustic parameter estimation describes the way in which useful descriptions of acoustic scenes can be parameterized and the signal processing algorithms that can be used to estimate the parameter values using spherical microphone arrays Subsequent chapters exploit these parameters including in particular measures of direction of arrival and of diffuseness of a sound field The array processing algorithms are then classified into two main classes each described in a separate chapter These are signal dependent and signal independent beamforming algorithms Although signal dependent beamforming algorithms are in theory able to provide better performance compared to the signal independent algorithms they are currently rarely used in practice The main reason for this is that the statistical information required by these algorithms is difficult to estimate In a subsequent chapter it is shown how the estimated acoustic parameters can be used in the design of signal dependent beamforming algorithms This final step closes at least in part the gap between theory and practice *Handbook on Array Processing and Sensor Networks* Simon Haykin,K. J. Ray Liu,2010-02-12 A handbook on recent advancements and the state of the art in array processing and sensor Networks Handbook on Array Processing and Sensor Networks provides readers with a collection of tutorial articles contributed by world renowned experts on recent advancements and the state of the art in array processing and sensor networks Focusing on fundamental principles as well as applications the handbook provides exhaustive coverage of wavelets spatial spectrum estimation MIMO radio propagation robustness issues in sensor array processing wireless communications and sensing in multi path environments using multi antenna transceivers implicit training and array processing for digital communications systems unitary design of radar waveform diversity sets acoustic array processing for speech enhancement acoustic beamforming for hearing aid applications undetermined blind source separation using acoustic arrays array processing in astronomy digital 3D 4D ultrasound imaging technology self localization of sensor networks multi target tracking and classification in collaborative sensor networks via sequential Monte Carlo energy efficient decentralized estimation sensor data fusion with application to multi target tracking distributed algorithms in sensor networks cooperative communications distributed source coding network coding for sensor networks information theoretic studies of wireless networks distributed adaptive learning mechanisms routing for statistical inference in sensor networks spectrum estimation in cognitive radios nonparametric techniques for pedestrian tracking in wireless local area networks signal processing and networking via the theory of global games biochemical transport modeling estimation and detection in realistic environments and security and privacy for sensor networks Handbook on Array Processing and Sensor Networks is the first book of its kind and will appeal to researchers professors and graduate students in array processing sensor networks advanced signal processing and

networking **Noise Reduction in Speech Processing** Jacob Benesty,Jingdong Chen,Yiteng Huang,Israel Cohen,2009-04-28 Noise is everywhere and in most applications that are related to audio and speech such as human machine interfaces hands free communications voice over IP VoIP hearing aids teleconferencing telepresence telecollaboration systems and so many others the signal of interest usually speech that is picked up by a microphone is generally contaminated by noise As a result the microphone signal has to be cleaned up with digital signal processing tools before it is stored analyzed transmitted or played out This cleaning process is often called noise reduction and this topic has attracted a considerable amount of research and engineering attention for several decades One of the objectives of this book is to present in a common framework an overview of the state of the art of noise reduction algorithms in the single channel one microphone case The focus is on the most useful approaches i e filtering techniques in different domains and spectral enhancement methods The other objective of Noise Reduction in Speech Processing is to derive all these well known techniques in a rigorous way and prove many fundamental and intuitive results often taken for granted This book is especially written for graduate students and research engineers who work on noise reduction for speech and audio applications and want to understand the subtle mechanisms behind each approach Many new and interesting concepts are presented in this text that we hope the readers will find useful and inspiring Acoustic Array Systems Mingsian R. Bai,Jeong-Guon Ih,Jacob Benesty,2013-04-30 Presents a unified framework of far field and near field array techniques for noise source identification and sound field visualization from theory to application Acoustic Array Systems Theory Implementation and Application provides an overview of microphone array technology with applications in noise source identification and sound field visualization In the comprehensive treatment of microphone arrays the topics covered include an introduction to the theory far field and near field array signal processing algorithms practical implementations and common applications vehicles computing and communications equipment compressors fans and household appliances and hands free speech The author concludes with other emerging techniques and innovative algorithms Encompasses theoretical background implementation considerations and application know how Shows how to tackle broader problems in signal processing control and transudcers Covers both farfield and nearfield techniques in a balanced way Introduces innovative algorithms including equivalent source imaging NESI and high resolution nearfield arrays Selected code examples available for download for readers to practice on their own Presentation slides available for instructor use A valuable resource for Postgraduates and researchers in acoustics noise control engineering audio engineering and signal processing *Study and Design of Differential Microphone Arrays* Jacob Benesty,Chen Jingdong,2012-10-23 Microphone arrays have attracted a lot of interest over the last few decades since they have the potential to solve many important problems such as noise reduction speech enhancement source separation dereverberation spatial sound recording and source localization tracking to name a few However the design and implementation of microphone arrays with beamforming algorithms is not a trivial task when it

comes to processing broadband signals such as speech Indeed in most sensor arrangements the beamformer output tends to have a frequency dependent response One exception perhaps is the family of differential microphone arrays DMAs who have the promise to form frequency independent responses Moreover they have the potential to attain high directional gains with small and compact apertures As a result this type of microphone arrays has drawn much research and development attention recently This book is intended to provide a systematic study of DMAs from a signal processing perspective The primary objective is to develop a rigorous but yet simple theory for the design implementation and performance analysis of DMAs The theory includes some signal processing techniques for the design of commonly used first order second order third order and also the general Nth order DMAs For each order particular examples are given on how to form standard directional patterns such as the dipole cardioid supercardioid hypercardioid subcardioid and quadrupole The study demonstrates the performance of the different order DMAs in terms of beampattern directivity factor white noise gain and gain for point sources The inherent relationship between differential processing and adaptive beamforming is discussed which provides a better understanding of DMAs and why they can achieve high directional gain Finally we show how to design DMAs that can be robust against white noise amplification **Techniques for Noise Robustness in Automatic Speech Recognition** Tuomas Virtanen,Rita Singh,Bhiksha Raj,2012-09-19 Automatic speech recognition ASR systems are finding increasing use in everyday life Many of the commonplace environments where the systems are used are noisy for example users calling up a voice search system from a busy cafeteria or a street This can result in degraded speech recordings and adversely affect the performance of speech recognition systems As the use of ASR systems increases knowledge of the state of the art in techniques to deal with such problems becomes critical to system and application engineers and researchers who work with or on ASR technologies This book presents a comprehensive survey of the state of the art in techniques used to improve the robustness of speech recognition systems to these degrading external influences Key features Reviews all the main noise robust ASR approaches including signal separation voice activity detection robust feature extraction model compensation and adaptation missing data techniques and recognition of reverberant speech Acts as a timely exposition of the topic in light of more widespread use in the future of ASR technology in challenging environments Addresses robustness issues and signal degradation which are both key requirements for practitioners of ASR Includes contributions from top ASR researchers from leading research units in the field *Fundamentals of Spherical Array Processing* Boaz Rafaely,2018-09-27 This book provides a comprehensive introduction to the theory and practice of spherical microphone arrays and was written for graduate students researchers and engineers who work with spherical microphone arrays in a wide range of applications The new edition includes additions and modifications and references supplementary Matlab code to provide the reader with a straightforward start for own implementations The book is also accompanied by a Matlab manual which explains how to implement the examples and simulations presented in the book The first two chapters provide the reader with the necessary

mathematical and physical background including an introduction to the spherical Fourier transform and the formulation of plane wave sound fields in the spherical harmonic domain In turn the third chapter covers the theory of spatial sampling employed when selecting the positions of microphones to sample sound pressure functions in space Subsequent chapters highlight various spherical array configurations including the popular rigid sphere based configuration Beamforming spatial filtering in the spherical harmonics domain including axis symmetric beamforming and the performance measures of directivity index and white noise gain are introduced and a range of optimal beamformers for spherical arrays including those that achieve maximum directivity and maximum robustness are developed along with the Dolph Chebyshev beamformer The final chapter discusses more advanced beamformers such as MVDR minimum variance distortionless response and LCMV linearly constrained minimum variance types which are tailored to the measured sound field Mathworks kindly distributes the Matlab sources for this book on https www mathworks com matlabcentral fileexchange 68655 fundamentals of spherical array processing **Speech Processing in Modern Communication** Israel Cohen,Jacob Benesty,Sharon Gannot,2009-12-18 Modern communication devices such as mobile phones teleconferencing systems VoIP etc are often used in noisy and reverberant environments Therefore signals picked up by the microphones from telecommunication devices contain not only the desired near end speech signal but also interferences such as the background noise far end echoes produced by the loudspeaker and reverberations of the desired source These interferences degrade the fidelity and intelligibility of the near end speech in human to human telecommunications and decrease the performance of human to machine interfaces i e automatic speech recognition systems The proposed book deals with the fundamental challenges of speech processing in modern communication including speech enhancement interference suppression acoustic echo cancellation relative transfer function identification source localization dereverberation and beamforming in reverberant environments Enhancement of speech signals is necessary whenever the source signal is corrupted by noise In highly non stationary noise environments noise transients and interferences may be extremely annoying Acoustic echo cancellation is used to eliminate the acoustic coupling between the loudspeaker and the microphone of a communication device Identification of the relative transfer function between sensors in response to a desired speech signal enables to derive a reference noise signal for suppressing directional or coherent noise sources Source localization dereverberation and beamforming in reverberant environments further enable to increase the intelligibility of the near end speech signal Design of Circular Differential Microphone Arrays Jacob Benesty,Jingdong Chen,Israel Cohen,2015-01-24 Recently we proposed a completely novel and efficient way to design differential beamforming algorithms for linear microphone arrays Thanks to this very flexible approach any order of differential arrays can be designed Moreover they can be made robust against white noise amplification which is the main inconvenience in these types of arrays The other well known problem with linear arrays is that electronic steering is not really feasible In this book we extend all these

fundamental ideas to circular microphone arrays and show that we can design small and compact differential arrays of any order that can be electronically steered in many different directions and offer a good degree of control of the white noise amplification problem high directional gain and frequency independent response We also present a number of practical examples demonstrating that differential beamforming with circular microphone arrays is likely one of the best candidates for applications involving speech enhancement i e noise reduction and dereverberation Nearly all of the material presented is new and will be of great interest to engineers students and researchers working with microphone arrays and their applications in all types of telecommunications security and surveillance contexts The Journal of the Acoustical Society of America Acoustical Society of America,2004 **Mathematical Reviews** ,2006 Deutsche Nationalbibliographie und Bibliographie der im Ausland erschienenen deutschsprachigen Veröffentlichungen ,2008 **Array Processing** Jacob Benesty,Israel Cohen,Jingdong Chen,2019-02-28 The focus of this book is on array processing and beamforming with Kronecker products It considers a large family of sensor arrays that allow the steering vector to be decomposed as a Kronecker product of two steering vectors of smaller virtual arrays Instead of directly designing a global beamformer for the original array once the steering vector has been decomposed smaller virtual beamformers are designed and separately optimized for each virtual array This means the matrices that need to be inverted are smaller which increases the robustness of the beamformers and reduces the size of the observations The book explains how to perform beamforming with Kronecker product filters using an unconventional approach It shows how the Kronecker product formulation can be used to derive fixed adaptive and differential beamformers with remarkable flexibility Furthermore it demonstrates how fixed and adaptive beamformers can be intelligently combined optimally exploiting the advantages of both The problem of spatiotemporal signal enhancement is also addressed and readers will learn how to perform Kronecker product filtering in this context **Speech Processing in Modern Communication** Israel Cohen,Jacob Benesty,Sharon Gannot,2010-02-04 Modern communication devices such as mobile phones teleconferencing systems VoIP etc are often used in noisy and reverberant environments Therefore signals picked up by the microphones from telecommunication devices contain not only the desired near end speech signal but also interferences such as the background noise far end echoes produced by the loudspeaker and reverberations of the desired source These interferences degrade the fidelity and intelligibility of the near end speech in human to human telecommunications and decrease the performance of human to machine interfaces i e automatic speech recognition systems The proposed book deals with the fundamental challenges of speech processing in modern communication including speech enhancement interference suppression acoustic echo cancellation relative transfer function identification source localization dereverberation and beamforming in reverberant environments Enhancement of speech signals is necessary whenever the source signal is corrupted by noise In highly non stationary noise environments noise transients and interferences may be extremely annoying Acoustic echo cancellation is used to eliminate the acoustic coupling

between the loudspeaker and the microphone of a communication device Identification of the relative transfer function between sensors in response to a desired speech signal enables to derive a reference noise signal for suppressing directional or coherent noise sources Source localization dereverberation and beamforming in reverberant environments further enable to increase the intelligibility of the near end speech signal

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Table of Contents Microphone Array Signal Processing Springer Topics In Signal Processing

1. Understanding the eBook Microphone Array Signal Processing Springer Topics In Signal Processing
    - The Rise of Digital Reading Microphone Array Signal Processing Springer Topics In Signal Processing
    - Advantages of eBooks Over Traditional Books
2. Identifying Microphone Array Signal Processing Springer Topics In Signal Processing
    - Exploring Different Genres
    - Considering Fiction vs. Non-Fiction
    - Determining Your Reading Goals
3. Choosing the Right eBook Platform
    - Popular eBook Platforms
    - Features to Look for in an Microphone Array Signal Processing Springer Topics In Signal Processing
    - User-Friendly Interface
4. Exploring eBook Recommendations from Microphone Array Signal Processing Springer Topics In Signal Processing
    - Personalized Recommendations
    - Microphone Array Signal Processing Springer Topics In Signal Processing User Reviews and Ratings
    - Microphone Array Signal Processing Springer Topics In Signal Processing and Bestseller Lists
5. Accessing Microphone Array Signal Processing Springer Topics In Signal Processing Free and Paid eBooks
    - Microphone Array Signal Processing Springer Topics In Signal Processing Public Domain eBooks
    - Microphone Array Signal Processing Springer Topics In Signal Processing eBook Subscription Services
    - Microphone Array Signal Processing Springer Topics In Signal Processing Budget-Friendly Options
6. Navigating Microphone Array Signal Processing Springer Topics In Signal Processing eBook Formats

- ePub, PDF, MOBI, and More
- Microphone Array Signal Processing Springer Topics In Signal Processing Compatibility with Devices
- Microphone Array Signal Processing Springer Topics In Signal Processing Enhanced eBook Features

7. Enhancing Your Reading Experience
   - Adjustable Fonts and Text Sizes of Microphone Array Signal Processing Springer Topics In Signal Processing
   - Highlighting and Note-Taking Microphone Array Signal Processing Springer Topics In Signal Processing
   - Interactive Elements Microphone Array Signal Processing Springer Topics In Signal Processing
8. Staying Engaged with Microphone Array Signal Processing Springer Topics In Signal Processing
   - Joining Online Reading Communities
   - Participating in Virtual Book Clubs
   - Following Authors and Publishers Microphone Array Signal Processing Springer Topics In Signal Processing
9. Balancing eBooks and Physical Books Microphone Array Signal Processing Springer Topics In Signal Processing
   - Benefits of a Digital Library
   - Creating a Diverse Reading Collection Microphone Array Signal Processing Springer Topics In Signal Processing
10. Overcoming Reading Challenges
    - Dealing with Digital Eye Strain
    - Minimizing Distractions
    - Managing Screen Time
11. Cultivating a Reading Routine Microphone Array Signal Processing Springer Topics In Signal Processing
    - Setting Reading Goals Microphone Array Signal Processing Springer Topics In Signal Processing
    - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Microphone Array Signal Processing Springer Topics In Signal Processing
    - Fact-Checking eBook Content of Microphone Array Signal Processing Springer Topics In Signal Processing
    - Distinguishing Credible Sources
13. Promoting Lifelong Learning
    - Utilizing eBooks for Skill Development
    - Exploring Educational eBooks
14. Embracing eBook Trends
    - Integration of Multimedia Elements
    - Interactive and Gamified eBooks

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