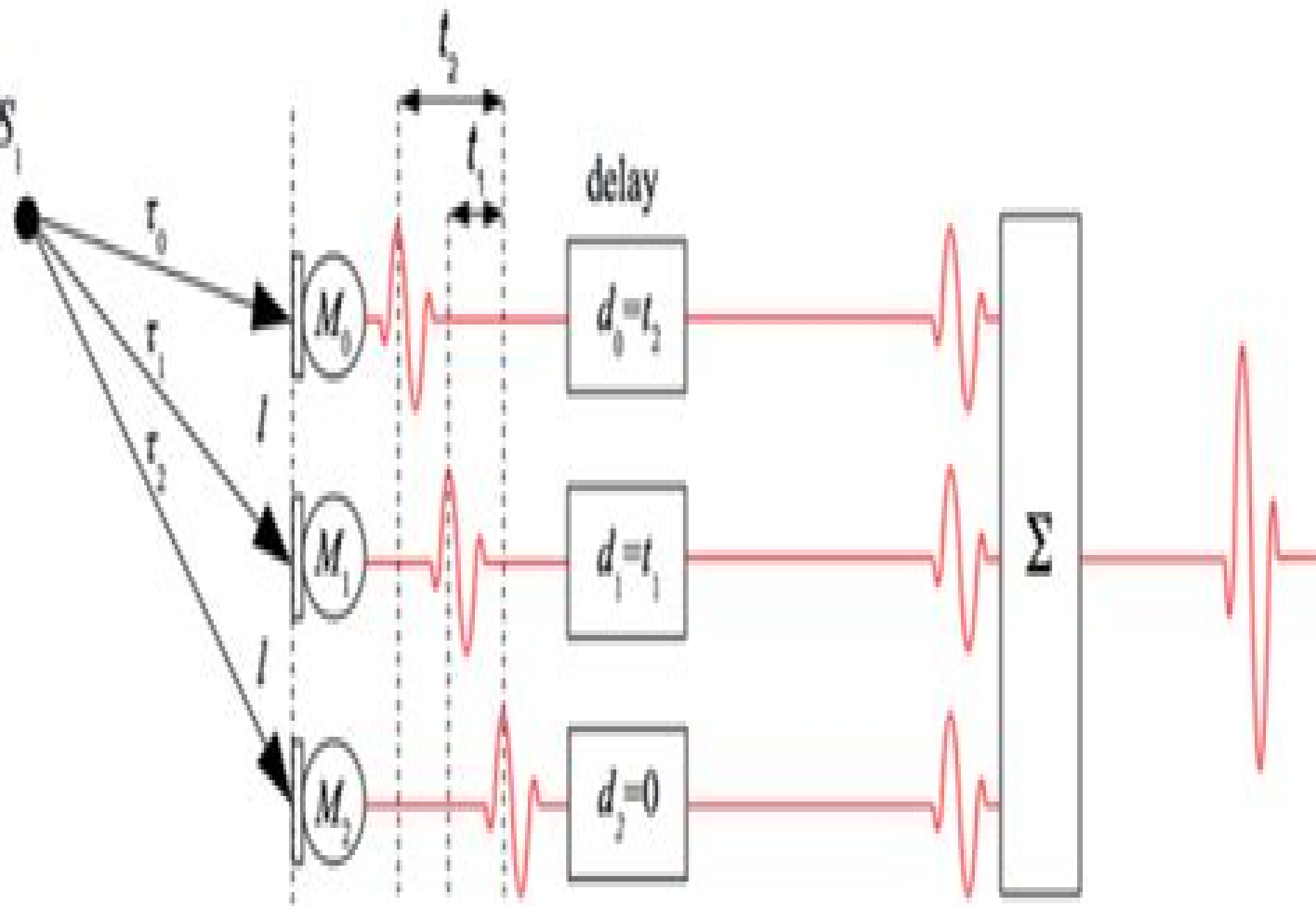




# Microphone Array Signal Processing Microphone Array Signal Processing

**Jacob Benesty, Chen Jingdong**



## **Microphone Array Signal Processing Microphone Array 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 acoustic and speech signal processing. The reason behind this endeavor is that there were almost no books available in the literature when we first 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 consequence 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 sensor arrays explained from a truly broadband perspective. Many algorithms for speech applications were simply borrowed from narrowband antenna arrays. However, a direct application of narrowband ideas to broadband speech processing may not be necessarily appropriate and can lead to many misunderstandings.

**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 researchers in the field to contribute articles addressing their specific topics of study. The reception we received from our colleagues was quite enthusiastic 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 theoretical in nature and emphasize the use of microphone arrays for speech enhancement and source localization, respectively. Part III presents a number of specific applications of array-based technology. Part IV addresses some open questions and explores the future of the field.

**Acoustic Array Systems** Mingsian R. Bai, Jeong-Guon Ih, Jacob Benesty, 2013-03-07 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 transducers 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      *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      **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

*A Study of Approaches for Microphone Array Signal Processing* Hnang Za Za, 2008

Microphone Array Signal Processing for Advancements in Robust Speech Systems Tao Yu, University of Texas at Dallas. Graduate Program in Electrical Engineering, 2011

Speech system performance degrades significantly in distant talking environments where the speech signals can be severely distorted by additive noise and reverberation Microphone array processing techniques have presented a potential alternative to close talking microphones by providing speech enhancement through spatial filtering and directional discrimination Different from conventional array optimization criteria such as Minimal Variance Distortionless Response Maximal Signal to Noise Ratio or Minimal Mean Squared Error this thesis presents a series of task oriented and environment oriented microphone array solutions for real world speech system applications Primarily four important tasks e g blind beamforming automatic speech recognition ASR speech quality enhancement and integrated voice activity detection VAD with speech enhancement are considered in two typical acoustic environments e g in vehicle and conference room Our objective is to optimize the microphone array front end at a system level directly advancing the performance of a given task for the whole speech system Specifically several new algorithms and systems are proposed in this thesis variance of spectra flux based blind beamforming to identify target speech source in in vehicle and conference room environments order statistic filter based squared spectra enhancement for ASR in in vehicle environment integrated VAD and speech quality enhancement system in in vehicle environment fast relative transfer function identification for speech quality enhancement and ASR in conference room position dependent spectra conversion for speech quality enhancement and ASR in in vehicle and conference room discriminative training based VAD for in vehicle environment and an efficient real time microphone array based speech acquisition platform Primary theoretical analysis and promising real simulation evaluations on the proposed algorithms are also presented in this thesis

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 beam pattern 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.

**Microphone Arrays** Michael Brandstein, Darren Ward, 2001-05-02 This is the first book to provide a single complete reference on microphone arrays. Top researchers in this field contributed articles documenting the current state of the art in microphone array research development and technological application.

**Sound Capture for Human / Machine Interfaces** Wolfgang Herboldt, 2009-09-02 With a continuously increasing desire for natural and comfortable human machine interaction the acoustic interface of any terminal for multimedia or telecommunication services is challenged to allow seamless and hands free audio communication. Sound Capture for Human Machine Interfaces introduces the practical aspects of microphone array signal processing and presents various combinations of beamforming and acoustic echo cancellation.

## **Microphone Array Signal Processing Microphone Array Signal Processing** Book Review: Unveiling the Magic of Language

In an electronic digital era where connections and knowledge reign supreme, the enchanting power of language has become more apparent than ever. Its power to stir emotions, provoke thought, and instigate transformation is actually remarkable. This extraordinary book, aptly titled "**Microphone Array Signal Processing Microphone Array Signal Processing**," written by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound effect on our existence. Throughout this critique, we will delve in to the book is central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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