



Fundamentals of Differential Beamforming (SpringerBriefs in Electrical and Computer Engineering)

Jacob Benesty, Jingdong Chen, Chao Pan

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This book provides a systematic study of the fundamental theory and methods of beamforming with differential microphone arrays (DMAs), or differential beamforming in short. It begins with a brief overview of differential beamforming and some popularly used DMA beampatterns such as the dipole, cardioid, hypercardioid, and supercardioid, before providing essential background knowledge on orthogonal functions and orthogonal polynomials, which form the basis of differential beamforming.

From a physical perspective, a DMA of a given order is defined as an array that measures the differential acoustic pressure field of that order; such an array has a beampattern in the form of a polynomial whose degree is equal to the DMA order. Therefore, the fundamental and core problem of differential beamforming boils down to the design of beampatterns with orthogonal polynomials. But certain constraints also have to be considered so that the resulting beamformer does not seriously amplify the sensors' self noise and the mismatches among sensors.

Accordingly, the book subsequently revisits several performance criteria, which can be used to evaluate the performance of the derived differential beamformers. Next, differential beamforming is placed in a framework of optimization and linear system solving, and it is shown how different beampatterns can be designed with the help of this optimization framework. The book then presents several approaches to the design of differential beamformers with the maximum DMA order, with the control of the white noise gain, and with the control of both the frequency invariance of the beampattern and the white noise gain. Lastly, it elucidates a joint optimization method that can be used to derive differential beamformers that not only deliver nearly frequency-invariant beampatterns, but are also robust to sensors' self noise.

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