Abstract

Spherical microphone array (SMA) signal processing has received much attention in the recent years for applications like higher-order sound field capture, analysis of room acoustics, direction of arrival (DOA) estimation, beamforming, and source separation. The widespread application of SMAs is due to the ease of array processing in the spherical harmonics (SH) domain without spatial ambiguity. Utilization of SH allows separation of variables for functions of DOA, sensor position, and wavenumber, thus facilitating frequency smoothing and dimensionality reduction. However, the construction of an SMA over a rigid sphere is a challenging task. Additionally, utilization of an entire sphere comes at the expense of a greater number of microphones and signals to process. It is also uneconomical to use an SMA when sources are present in restricted regions of the environment. Attempts have been made to use hemispherical microphone arrays on the basis of the acoustic image principle, enabling application of SH but with greater computational complexity.

As a part of the thesis, utilization of spherical sector microphone array is proposed. An orthonormal spherical sector harmonics (S^2H) basis function is developed for accurate representation of pressure over the sector. The orthonormality of the S^2H function is established using orthogonality of shifted associated Legendre polynomials and a scaled exponential function. The discontinuity over the boundary is handled by solving the Helmholtz equation over the sector. An expression for the sectoral mode strength for an open and rigid spherical sector is derived based on exact solution to the wave equation. An addition theorem for S^2H basis functions is established to account for an incident field angle in the plane-wave solution to the wave equation. The norm of the S^2H basis function is computed using S^2H addition theorem.

Subsequently, source localization, beamforming, and source separation problems are formulated in spherical sector harmonics domain. The new S^2H basis functions are utilized for far-field and mixed-field data model development. An ideal direction-invariant beampattern and maximum directivity white noise gain (MD-WNG) beamformer are proposed for the spherical sector microphone array. Simulation and real experiment results are presented for narrowband and wideband signals.