The 11th East Asia Mechanical and Aerospace Engineering Workshop
4-6 November 2025, Sapporo, Japan

A Comparative Study of Beamforming Algorithms for Direction-of-Arrival Estimation of Environmental Noise Sources

Sanjaya RAI[1], Randolph Chi Kin LEUNG[1] and Catherine Wai Man LEUNG[2]

[1]Department of Mechanical Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, P. R. China
23132837r@connect.polyu.hk, mmrleung@polyu.edu.hk
[2]MTR Corporation Limited, MTR Headquarters Building, Telford Plaza, Kowloon Bay, Kowloon, Hong Kong, P. R. China
cwmleung@mtr.com.hk

ABSTRACT: Accurate direction-of-arrival (DOA) estimation of environmental noise sources is essential for effective environmental noise monitoring and management in urbanized cities. The present study focuses on the development of a compact uniform circular microphone array (UCMA) with eight microphones, which has high potential for capturing the spatial characteristics of environmental noise in complex urban spaces. We investigate and compare the performance of UCMA for DOA estimation using three beamforming algorithms, namely delay-and-sum (DAS), steered response power with phase transform (SRP-PHAT), and multiple signal classification (MUSIC). DAS offers a simple and efficient method for DOA estimation but may perform poorly in noisy background. SRP-PHAT improves accuracy through phase-weighted processing, enhancing robustness to background noise and reverberation. MUSIC, based on subspace decomposition, delivers high resolution for closely spaced sources but with greater computational demands. We conducted an extensive evaluation of the performance and suitability of these algorithms for deploying the UCMA in practical urban noise source DOA estimation through numerical simulations and laboratory experiments. The evaluation results show that SRP-PHAT and MUSIC outperform DAS under challenging noise source conditions, with MUSIC achieving the best precision despite its higher computational needs. Details of the study will be discussed.

KEYWORDS: Environmental noise, direction-of-arrival, uniform circular microphone array, beamforming algorithms, delay-and-sum.