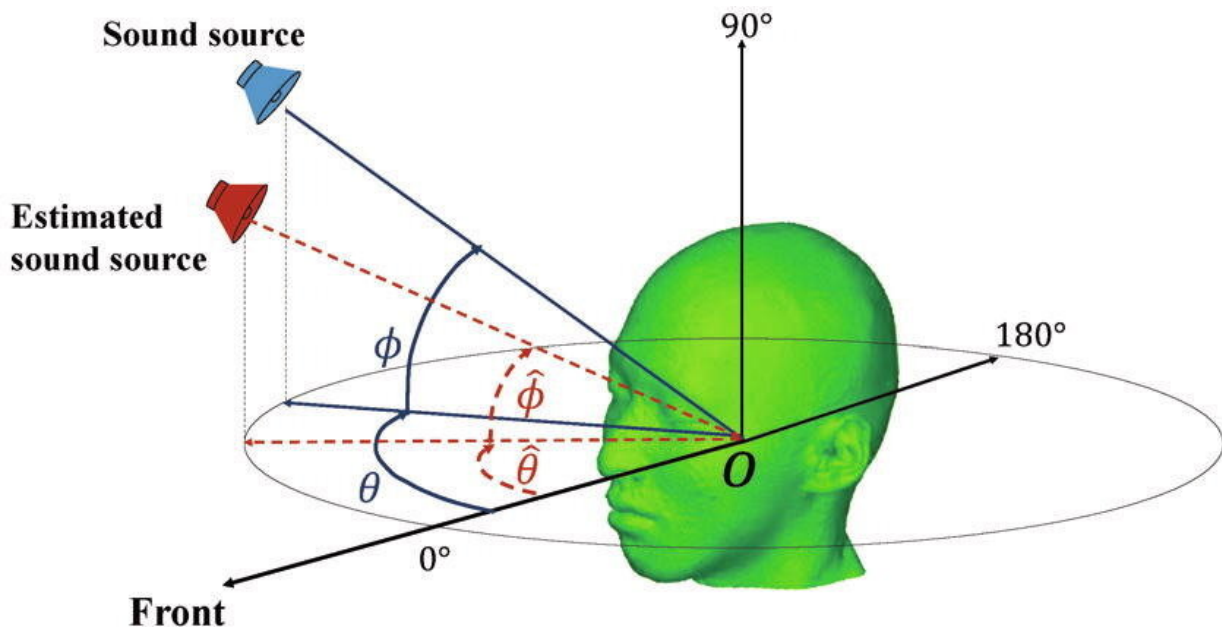


Understanding sound direction estimation in monaural hearing

March 14 2023



Researchers from Japan propose a method for estimating sound direction from monaural hearing that takes into consideration how an individual's head, torso, and ears affect their perception of the sound source. Credit: Masashi Unoki from JAIST.

The ability to locate sounds in the surrounding environment is a remarkable feature of the human ear. Typically, people with good hearing use both ears to detect and interpret auditory cues.

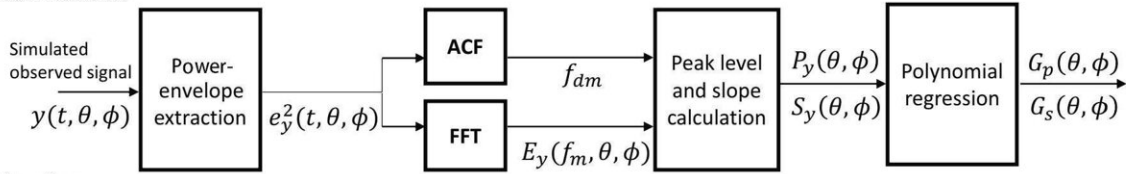
Differences in the loudness or arrival time of sounds at each ear provide us with vital information about the location and direction of the sound source. Interestingly, however, studies have suggested that while binaural cues are sufficient for sound localization, they are not necessary. People with monaural hearing (hearing loss in one ear) can perceive sound location as well.

Fortunately for engineers, this can help remove limitations on the design and positioning of audio recording devices and microphone arrays. Used for source localization and [noise reduction](#), microphone arrays need to be placed at specific intervals and positions to effectively capture and analyze sound from different directions. To avoid poor sound quality resulting from inadequate microphone array design or positioning, the capability to estimate the sound direction using monaural cues is highly desirable as it can help simplify microphone array designs.

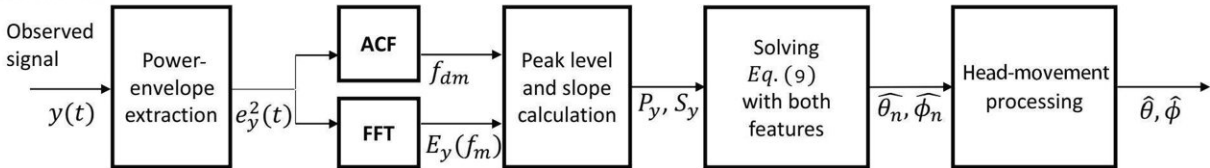
In a study published in *Applied Acoustics*, Prof. Masashi Unoki and his colleagues from the Japan Advanced Institute of Science and Technology (JAIST) and Toyama Prefectural University, Japan, have proposed a method that uses monaural cues to estimate the direction-of-arrival (DOA) of sound signals in three dimensions.

"In our work, we propose an estimation method based on monaural modulation spectrum (MMS), which relies on modulation in the [frequency spectrum](#) of the received signal to detect the signal DOA. This can help us develop monaural cues for single-channel [signal processing](#)," explains Prof. Unoki.

1. Model features



2. Estimation



The proposed model is trained to estimates the DOA of sound signals based on the extracted features of the monaural modulation spectrum of the signal. Credit: Masashi Unoki from JAIST.

To determine the monaural DOA, the team simulated sound signals from different directions using artificial amplitude modulation noise and human speech signals while accounting for the effect of the ears, torso, and head in filtering sound. Next, they obtained the MMS of the signals describing their frequency modulations to identify key features that could be tied to the DOA of the signals.

To avoid monaural front-back confusion, which occurs when sound sources at the same angle in front of or behind the listener can produce the same estimates for the DOA, the researchers considered the effect of head movement on the MMS to realize a more accurate DOA estimation.

Using the known DOA and the features of the MMS as training data, they then constructed a polynomial regression model that estimated the DOA from the MMS features of the sound signal in terms of the horizontal and the vertical direction of the listener. The model could accurately estimate the DOA of 829,440 speech signals, outperforming

even human monaural hearing.

While the team qualifies their findings by suggesting that there is more work to be done to account for [background noise](#) and [individual differences](#) in ear shape when creating the model, the study demonstrates an impressive advancement in monaural sound localization. Speculating about its implications, the researchers envision their technology's applications in [sound](#) surveillance techniques and hearing aid enhancements.

"Our study will help reveal our ability to localize sounds based on monaural hearing, which, in turn, could stimulate various innovations in hearing aid techniques in the long-term," concludes Prof. Unoki.

More information: Rui Wang et al, Method of estimating three-dimensional direction-of-arrival based on monaural modulation spectrum, *Applied Acoustics* (2023). [DOI: 10.1016/j.apacoust.2023.109215](#)

Provided by Japan Advanced Institute of Science and Technology

Citation: Understanding sound direction estimation in monaural hearing (2023, March 14) retrieved 26 April 2024 from <https://medicalxpress.com/news/2023-03-monaural.html>

<p>This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.</p>
--