Advanced source localization techniques using microphone arrays

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Microphone arrays used in vehicle acoustics are mainly designed for fast setup and basic evaluation (e.g. using delay-and-sum beamforming) resulting in a restriction to free field environments. Applications in vehicle interiors require advanced source localization techniques taking into account the reflections at the different panels appearing as mirror sources.

Coherence filtering techniques allow for the detection of these mirror sources. An additional sensor is placed as a reference close to the main source. This reference signal is used to filter the array signals increasing the overall dynamic range of the acoustic source mapping. The discrimination of the original source and the reflections are obtained by manipulating the impulse responses between the reference signal and all microphone signals.

Other advanced signal processing techniques can be used to increase the limited dynamic range of conventional beamforming such as principal component analysis removing the dominant sources. An implementation allowing for online application based on spatial filters will be presented.

Different approaches are compared for localization in smaller rooms like vehicle cabins with respect to robustness and usable frequency range within the given constraints - still a challenging task in many research projects.

In addition the production requirements of large scale arrays for e.g. wind tunnel measurement and pass-by or fly-over measurements are discussed. Manufacturing a large scale array with an appropriate precision for the microphone positions and the video system would be very expensive. A very efficient solution turns out to be a combination of a small calibrated camera module (consisting of a video system plus a small number of microphones with high-precision positioning) and a large scale array containing microphones with low precision positioning. Array measurements using a standard loudspeaker for excitation serve as input for nonlinear optimization techniques to identify the positions of all microphones based on the orientation of the camera module. The techniques allow also for combining small arrays to increase the spatial resolution.

This paper describes the theoretical background of different source localization techniques based on microphone arrays. Application examples are used to illustrate not only their advantages but also their potential drawbacks.

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