Inverse acoustics IBEM vs. PNAH

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Introduction

A thorough understanding of the mechanisms that cause noise in a technical product is vital to noise reduction. Therefore, the development of acoustic source identification techniques is a blooming field of research. A general scheme for these techniques is depicted in figure 1.
First, acoustic measurements are performed on a large number of points close to the surface of an object radiating noise. Secondly, a *forward acoustic model* is used to calculate the transfer from the radiating object to the field. Thirdly, the transfer matrix is inverted. Since it is ill-conditioned (close to singular), *regularization techniques* are employed. Finally, the measurement data and the inverse matrix are used to determine the acoustic sources.

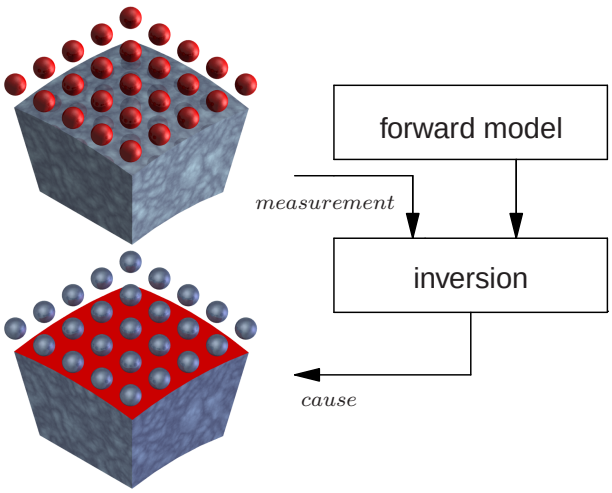

Figure 1 : inverse acoustics. Spheres: acoustic sensors. Cubic object: radiating surface

Objective

The objective of the STW project *inverse acoustics* is to develop improved techniques for acoustic source identification. The similarities and differences between two common methods in inverse acoustics are summarized here.

IBEM

IBEM (Inverse Boundary Element Method) relies on a forward acoustic model based on the Boundary Element Method (BEM) and is applicable to arbitrary 3D geometries. In IBEM, the transfer matrix is usually calculated explicitly. The inversion of this ill-conditioned matrix is achieved by applying a (regularization) filter to the spectrum – the singular value decomposition (SVD) – of the transfer matrix.

PNAH

PNAH (Planar Nearfield Acoustic Holography) is applicable to planar geometries only. It relies on a spatial Fourier transform of the acoustic field to form a forward acoustic model. Although this model is exact for acoustic fields that are spatially periodic, an error arises when it is applied to actual (nonperiodic) acoustic measurements. The forward model does not need to be calculated explicitly because the spectrum of the transfer can be obtained through a spatial FFT of the measurement data. Details aside, this spectrum is equal to the SVD of the transfer matrix. Hence, the regularization filters that are applied in IBEM can also be applied in PNAH and vice versa.

Discussion

- IBEM and PNAH are both examples of a more general method. Differences lie in the forward model used.
- PNAH can be applied in real time, whereas IBEM requires prior calculations.
- The effect of the limited accuracy of PNAH on the quality of the reconstruction is still a matter of debate.

Further research

- Improved techniques for the validation of reconstructed sources.
- Fast ($O(n \log n)$) methods with high accuracy, for both planar and arbitrary geometries.
- An array of acoustic sensors for improved data acquisition.