PROPOSITION DE STAGE – MASTER 2 DET
Dynamique des fluides, Énergétique et Transferts
Université Toulouse 3 Paul Sabatier – Toulouse INP – INSA Toulouse – ISAE-SUPAERO – IMT Mines Albi

Titre : Complex aeroacoustic sources study by means of source localization methods

Responsable(s) : Hélène Parisot-Dupuis (ISAE-SUPAERO, DAEP) & Fabien Méry (ONERA, DMPE)
Lieu du stage : Aerodynamics & Propulsion Department (DAEP), ISAE-SUPAERO, Toulouse, FRANCE

Durée / période : 6 months

Candidature [CV, lettre de motivation, références] à envoyer à : helene.parisot-dupuis@isae-supaero.fr & fabien.mery@onera.fr

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Keywords: source localization, aeroacoustics, signal processing, programming, experiments and/or numerical post-processing

Context:

Global economic and demographic expansion is leading to an increase in noise pollution associated with land and air transportation as well as new energy developments (wind power). Noise pollution regulations are becoming increasingly strict and the reduction of aerodynamic noise sources, known as aeroacoustics, is therefore a major challenge. The characterization of aeroacoustic sources in the pre-project phase by means of wind tunnel tests is a key step to help understand noise generation mechanisms and to be able to develop effective noise reduction strategies.

For this purpose, various source localization techniques have been developed. The most well-known is called Beamforming and was developed by Billinglsey and Kinns [1] in 1974. This technique assumes that the sound field radiated by the sources under study follows a certain source model (usually uncorrelated monopoles). It is then possible to localize the acoustic sources from farfield microphone measurements by interpreting the propagation delays measured between each microphone of the antenna and by knowing the source-antenna distance. However, the use of inverse methods is required to improve sound sources level assessment and maps resolution. Different methods based on deconvolution algorithms have been developed for that purpose: CLEAN [2], DAMAS [3].

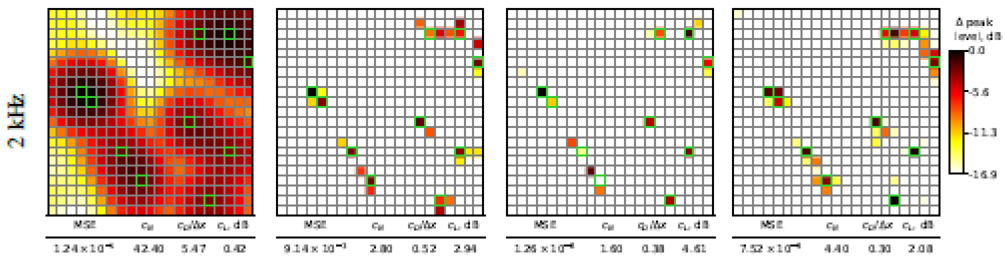

Figure 1 : Comparison of acoustic maps obtained by conventionnal beamforming (CBF), deconvolution methods (CLEAN, DAMAS) and convolutional neural network (CNN) for 10 sources positionned randomly at 2 kHz [5].

More recently, source localization techniques based on bayesian statistics [4] (previously used for the characterization of porous materials [5] or the impedance reduction of liners under grazing flow [6]) and deep learning [7] have also been developed. These techniques offer an original solution to the inverse problem of acoustic source localization. Work has been done in recent years to evaluate the potential of these methods on simple test cases.

Content:

Previous internships allowed to develop a systematic methodology to assess source maps quality by means of automatic source detection and performances criteria. The first step of this internship will be to learn about sound source localization and to take in hand, and improve if needed, this code. Then this methodology will be applied to a database of microphone array measurements performed in anechoic room on controlled sources (loudspeakers). The aim of this part will be to assess the effect of various parameters (array configuration & position, sources nature, masking & reflection, localization algorithm) on source maps accuracy. Particular attention will be paid to sound source localization limitations known from the literature: a single source model for the whole source map, ideal environment… Depending on the progress of the internship two paths could then be followed. The first would consist in choosing in the first part the more appropriate combination of array and algorithm to study aeroacoustic sources of increasing complexity (convected monopolar source, airframe elements, rotor alone or in interaction with a beam) coming from experiments or LES simulations. Another would be to try to extend source localization methods available in the literature for aeroacoustic sources configurations for which they do not provide accurate source maps (mix of monopolar/dipolar uncorrelated/correlated sources, multiple interaction effects, rotating sources…).

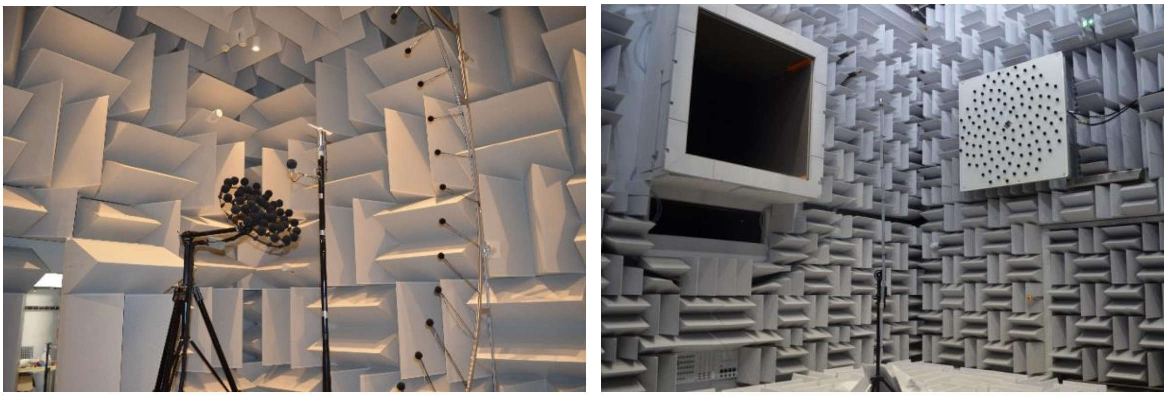

Figure 2: Localization arrays in ISAE-SUPAERO anechoic room and aeroacoustic wind tunnel.

Expected profile:

We are looking for candidates with a background in aeroacoustics. Knowledge in signal processing is a plus to approach this theme. Candidates will also be required to program in Matlab and/or Python.

Bibliography:

[1] J. Billinsgley and R. Kinns, « The acoustic telescope », J. Sound Vib. 48 (4), 485-510 (1976).
[2] R. P. Dougherty and R. W. Stoker, « Sidelobe suppression for phased array aeroacoustic measurements », In 4th AIAA/CEAS Aeroacoustics Conference, AIAA 1998-2242 (1998).
[3] T. F. Brooks and W. M. Humphreys Jr, « A Deconvolution Approach for the Mapping of Acoustic Sources (DAMAS) Determine from Phased Microphone Arrays », In 10th AIAA/CEAS Aeroacoustics Conference, AIAA 2006-2654 (2006).
[4] J. Antoni, « A Bayesian approach to sound source reconstruction: Optimal basis, regularization, and focusing », J. of the Acoustical Soc. of America, 131, 2873-2890 (2012).
[5] R. Roncen, Z. E. A. Fellah, F. Simon, E. Piot, M. Fellah, E. Ogam, C. Depollier, “Bayesian inference for the ultrasonic characterization of rigid porous materials using reflected waves by the first interface”, The Journal of the Acoustical Society of America 144 (1) (2018) 210–221. doi:10.1121/1.5044423.
[6] R. Roncen, F. Méry, E. Piot and F. Simon, “Statistical Inference Method for Liner Impedance Eduction with a Shear Grazing Flow”, AIAA Journal 57(3) (2019).
[7] W. Gonçalves Pinto, M. Bauerheim, H. Parisot-Dupuis, “Deconvoluting acoustic beamforming maps with a deep neural network." INTER-NOISE and NOISE-CON Congress and Conference Proceedings. Vol. 263. No. 1. Institute of Noise Control Engineering, (2021).
[8] N. Chu, Y. Ning, L. Yu, Q. Huang and D. Wu, "A High-Resolution and Low-Frequency Acoustic Beamforming Based on Bayesian Inference and Non-Synchronous Measurements," in IEEE Access, vol. 8, pp. 82500-82513, 2020, doi: 10.1109/ACCESS.2020.2991606.