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PROPOSITION DE POST-DOCTORAT

Intitulé : De-reverberation and Denoising source signals for closed wind tunnel applications

Référence : **PDOC-DAAA-2019-04**
(à rappeler dans toute correspondance)

Start : 2nd semester 2019	**Application deadline :**

Duration : 12 months, possibly extendable to 24 months - Net yearly salary: about 25 k€

Keywords

De-reverberation, Denoising, Wind Tunnel Testing, MIMO Systems Identification, Acoustic source separation

Profile of the candidate

We seek a candidate with a PhD degree acoustic signal processing. Strong experience in acoustic signal processing is mandatory. The successful applicant should be strongly motivated, have the capability to work in autonomy as well as in collaboration with colleagues and students at ONERA. Good knowledge in both written and spoken English is required.

Skills :

- Strong signal processing experience applied to inverse problem in acoustic
- Good knowledge of Matlab and Fortran
- Previous publications in peer-reviewed journal
- An experience in acoustic data processing using BSS will be an advantage

Context

In today's society, noise pollution is an important problem which affects a large part of the population. Although most people appreciate the advantages of air transport, the accompanying noise often causes public concern. This brings the aeronautic industry to investigate new aircraft generations that are more and more quiet. An important step to reach this goal is based on acoustic tests mainly carried out in open-test section, under free-field conditions and low background noise to accurately characterize the acoustic sources of interest. Anechoic so-called open-jet wind tunnels (lack of reflective walls) are designed to meet these two requirements. The tendency around the world, including Onera, is to reduce the costs and the duration of the experimentations by carrying out the aerodynamic and acoustic tests in the same closed wind tunnels initially developed to perform accurate aerodynamic measurements. Compared to the open-jet wind tunnel, the closed wind-tunnel offers a broad spectrum of test conditions typically seen in industrial testing, to push the innovative technologies to their limitations. However, with closed wind tunnels we are facing to a complicated acoustic environment [1]. In the pressure output from the microphones (generally flush mounted), the signals due to the acoustic sources are mixed with two kinds of spurious phenomena:

- reverberation resulting of multipath propagation of the acoustic sources introduced by the wall of the test section not equipped with acoustic liner,
- background noise due to the wind tunnel operation itself, including engine noise, fan noise and vibrations which are propagated in the circuit.

Objective

The objective of the present post-doctoral position is to develop diverse acoustic signal processing techniques to circumvent these two drawbacks. They include acoustic source de-reverberation, noise reduction [2, 3] and acoustic source separation. Generally, the numbers of inputs (the primary sources) and outputs (the microphones) of the acoustic system are taken into account for the choice of algorithms and their complexity. In the case of tests in wind tunnel, the aircraft model may radiate several acoustic sources simultaneously on the array of microphones, thus, defining a so-called MIMO structure (Multiple-Input Multiple-Output), performing a multichannel convolution with the wave forms of the acoustics components.

Project

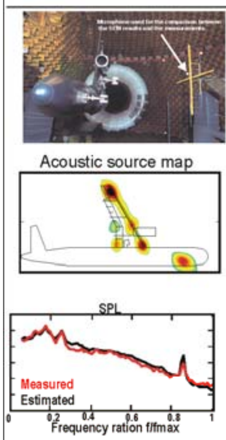
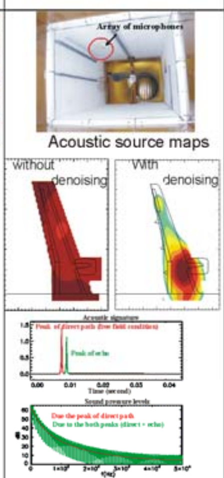
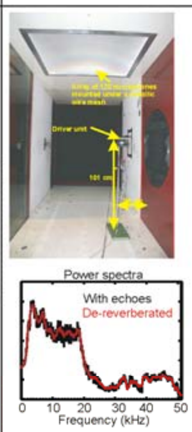
The main difficulty in this study is that one wants to extract multiple primary sources of interest starting from a given set of noisy observations, when these primary sources and the impulse responses characterizing both the propagation channels between each source and the microphones, and the reverberant effects, are unknown.

This problem arises in a variety of engineering and science areas such as seismic exploration, digital communications, speech signal processing, ultrasonic non-destructive evaluation, and underwater acoustics. It has been successfully solved for a single source scenario - i.e. a SIMO structure (Single Input Multiple Output), using a multimicrophone cepstral method [4].

Nevertheless, this is a difficulty preventing the extension of this method to the MIMO because the algebraic property of the logarithm function i.e. to change a product into a sum does not hold for any matrices. A solution is proposed in [5] to circumvent this difficulty. It consists to convert a MIMO system into a number of SIMO systems by separating the spatial and temporal components of the interferences at the output of a MIMO system. The SIMO systems obtained should be able to be used by the multimicrophone cepstral method to dereverberate the acoustic measurements.

Another solution to solve the problem considered is based on blind equalization, also known as blind deconvolution of the MIMO system [6]. The primary input signals may be obtained with an optimum equalizer applied to the MIMO outputs but generally up to a scale factor and a time delay. It will be necessary to study how to remove these two drawbacks for obtaining acoustic data with a good accuracy.

In the proposed study, we will focus on the specificities of aeroacoustics, namely, a very bad signal-to-noise ratio, stationary acoustic sources which may be broadband (or tonal), with non-isotropic directivity. The extraneous noises introduce unacceptable errors in the measurements therefore they can be an obstacle to accurately characterize acoustic sources on location maps [7, 8, 9], and a serious limitation to obtain good performance of advanced signal processing methods that will be implemented. Various techniques of denoising have been intensively studied in the last decades and the literature dealing with the topic extremely rich. A selection of the most suitable methods will be done to deal with very noisy signals, typically those measured in the closed wind tunnels [10] by comparison to those measured in an open test section [11].

Test in anechoic wind tunnel	Tests in reverberant wind tunnel	De-reverberant solution for a signe source senrrio	De-reverberant and denoising solutions for multiple source scenarios
			**TO DO**
Good acoustic sources characterization but at low frquency	Bad acoustic sources characterization due to high background noise and reverberation effects	Results with a multimicrophone cesptral method	Denoising solutions have been deveoped for the acoustic maps but not for the measured signals in MIMO situations

Activities

1. Study of different strategies to convert MIMO system into SIMO systems with assessment on simple test cases (without and with background noise)
2. Assess the methods of step 1 with data of numerical simulations conducted on simple and complex cases (without and with flow without and with reverberant effects)
3. Assess the methods with experimental database measured in a closed test section
4. Study different strategies to solve the MIMO problem with blind deconvolution.
5. Assess blind deconvolution solutions on simple cases (with noise free, without and with reverberant effects)

Expected outcomes

Improvement of acoustic measurements in reverberant and noisy facility in the case of multi-sources

References

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[8] T. Brooks, « A Deconvolution Approach for the Mapping of Acoustic Sources (DAMAS) Determined from Phased Microphone Arrays, » 10th AIAA/CEAS Aeroacoustics Conference, Manchester, Great Britain, 10-12 May, 2004, AIAA Paper No. 2004-2954.

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Collaborations

Host Laboratory at ONERA

Department : Aerodynamics, Aeroelasticity, Acoustics

Location (ONERA Center) : Châtillon

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