Post-Doc/Research position in sound source separation

Place: TELECOM ParisTech, Paris, France
Duration: 1 year
Start: Any date from September 1st, 2016
Salary: according to background and experience

*Position description*

The position is funded by the DESIR project, which brings together the Institut Langevin, the ISAE (Higher Institute of Aeronautics and Space), SAFRAN (Safran Tech and Safran Aircraft Engines), and Télécom ParisTech. The objective of this project is the vibro-acoustic monitoring of motors, by the search for weak signals in acoustic data, signaling the presence of bearing defects. This project is subdivided into two packages: Package 1 (Active Monitoring), which analyzes the possibilities of time reversal on a simple mechanical system, and Package 2 (passive monitoring), which aims to analyze the possibilities offered by applying multidimensional signal processing approaches to acoustic signals taken from a turbojet engine. Within this project, the contribution of Télécom ParisTech focuses on research and development of signal processing techniques (source separation and spectral analysis methods). It is part of Package 2.

The data to be analyzed are signals from acoustic sensors (or vibration sensors / accelerometers) placed on or near the engine. It is also envisaged to process acoustic signals picked up, in particular, by smart phones in the passenger compartment of the aircraft or by sensors placed on the tarmac at airports.

Problem to be addressed

In order to detect the presence or absence of defects in certain elements of the engine, we propose to use signal processing methods specific to the problem of "source separation". Indeed, these methods will make it possible to extract the signals emitted by each element of the engine, from the observation of mixtures of these signals on several sensors. Since the frequency signature of the source signals is known, in the presence and absence of defects, this will make it possible to carry out the detection.

The conventional problem of source separation consists in separating $J$ source signals from the observation of $I$ mixtures of these signals. The techniques to be implemented depend on the assumptions made on the one hand on the source signals: statistically independent / non-independent sources, IID processes (independent and identically distributed) / non-IID processes, Gaussian / non-Gaussian processes, and on the other hand on the type of mixture: (over-)determined ($I \geq J$) / under-determined ($I < J$), linear / nonlinear, instantaneous / convolutive / non-convolutive. The most popular separation techniques aim to blindly separate determined, linear and instantaneous mixtures of independent source signals, which are either IID and non-Gaussian, or non-IID and Gaussian. These techniques are based on independent component analysis (ICA) [Cardoso 98].

In the context of the DESIR project, the sources of noise in a jet engine are fans, drive shafts, combustion chambers and accessory gearboxes, also called AGBs. These sources are unfortunately not independent, as they are all mechanically linked, via the combustion chamber. It is therefore expected that ICA techniques will have limited performance in this type of configuration. Moreover, the mixture is indeed linear, but it is not instantaneous, because of the propagation time of acoustic waves. In theory, the propagation of an acoustic wave from one point of space to another is convolutive, but here, since the sources are not pointwise, the mixture is unlikely to be precisely modeled by a product
of convolution. Finally, since the number of sensors that can be used is not constrained, it is preferable to place oneself in the favorable context of a (over-)determined mixtures (more sensors than sources).

In summary, the mixtures to be processed will be (over-)determined, linear but a priori non-convolutive, and the sources are not statistically independent. Due to the difficulty of this separation problem, the probabilistic model of source signals should be chosen carefully, in order to exploit any a priori information that would be available on these signals. For example, it is known that non-Gaussian models provide greater robustness than Gaussian models [Liutkus 15]. Moreover, it would be judicious, rather than using an IID process model without any information on the sources, to exploit, on the contrary, the dynamics of the source signals in the time-frequency domain. For example, it has been observed that in a jet engine the sources occupy different, sometimes disjoint frequency bands. In addition, some sources are harmonic, and may have different fundamental frequencies. Thus the sources related to the gears are periodic, while other sources have a random, cyclo-stationary, character [Gardner 06] (for example, rolling defects are cyclo-stationary at order 2).

Finally, the problem of source separation is close to that of the location of these sources in space. Thus, it will be possible to exploit the knowledge of the spatial localization of the sources when it is available, for example by using methods such as beamforming [Van Veen 88], or to seek to jointly solve both problems of source separation and localization.

Project outline

The first phase of the project will analyze the available data in order to define suitable source signals and mixtures models. In particular, it will be possible to estimate the periodicity, the spectrum or the cyclo-stationarity of the signals, and to measure the transfer functions of the mixtures. The second phase of the project will focus on source separation methods. Several existing methods will be tested in order to study their performance in this context, as well as their limitations, and one or more dedicated methods based on the results of the first phase will be developed and evaluated on synthetic and real data, in terms of separation performance and calculation cost.

*TELECOM ParisTech*

TELECOM ParisTech is the leading graduate School of Institut Mines-Télécom, with more than 160 research professors and over 250 Engineering degrees, 50 PhD and 150 specialised masters (post graduates) awarded per year. The Signal, Statistiques et Apprentissage (S2A) research group, headed by Prof. Stéphan Clémençon, gathers 20 permanent staffs, 15 post-docs and 34 PhD students. In the research theme Audio Data Analysis and Signal Processing (ADASP), headed by Dr. S. Essid, the group has developed a strong expertise in source separation, indexing, Audio3D compression, dereverberation/denoising...


Candidate Profile

As minimum requirements, the candidate will have:

- A PhD in audio or multimedia signal processing, acoustics, speech processing, statistics, machine learning, computer science, electrical engineering, or a related discipline.
- Some knowledge in audio signal processing.
- Programming skills in Matlab, C/C++.

The ideal candidate would also have:

- Solid knowledge of source separation techniques and statistical signal processing
- Ability to work in a multi-partner collaborative environment.
- Strong communication skills in English.
- Basic knowledge of French (not required).

Contacts

Interested applicants can contact Gaël Richard or Roland Badeau for more information or directly email a candidacy letter including a Curriculum Vitae, a list of publications and a statement of research interests.

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References


