The **French-German Research Institute of Saint-Louis (ISL)** situated in the border triangle of Germany, France and Switzerland is an internationally renowned research institute belonging to a global industrial and economic network.
The spectrum of our core activities comprises a variety of topics: aerodynamics, energetic and advanced materials, lasers and electromagnetic technologies,
protection, security and situational awareness. Our activities are related to both basic and applied research.

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Keywords: Deep learning, Acoustic detection, UAV, noise reduction, experimental tests, signal processing

Deep learning applied to multichannel noise reduction of audio signals captured by a microdrone mounted microphone array

Context

The development of flying drones has led to an increase in the number of use cases in the civilian and military fields. While their use applied to video for surveillance, detection, or simply leisure is now well known to professionals and the public, the use of acoustic signals from an onboard microphone array represents a new challenge for researchers. The easy deployment of UAVs, combined with microphone array processing techniques, could allow the application of methods for sound environment restitution or event detection over a large area of operation. Search and rescue of casualties, in case of disaster or on the battlefield, is a use case of growing interest.

Objective

The objective of this PhD research is to implement denoising techniques for signals measured using microphones mounted on an unmanned aerial vehicle. The noise produced by the flying aircraft affects the ability to use embedded microphones to monitor events on the ground (vehicle movements, calls for help, conversations, etc.). The denoising techniques developed in this project, which are based on deep neural network techniques, should allow to detect events of interest occurring on the ground. We also wish to evaluate the deep learning methods against standard denoising methods in various stages of the signal processing, using the microphone array and the attitude sensors data embedded on the UAV.
Exiting database will be enriched with measurements made at the ISL in an anechoic chamber and in an outdoor representative environment, and at the LMSSC using a sphere of loudspeakers allowing the generation of a controlled acoustic environment. The performance of the studied algorithms can be measured using statistical methods and subjective methods.

Goal/tools of the proposed thesis

Regarding the architecture of the neural networks developed during the thesis, a specific attention will be paid to the implementation on embedded systems. Performance constraints tend to be in favor of end-to-end architectures using raw signals (in the time domain) as inputs.

First, a bibliographic survey of relevant Deep Learning methods (type of input data: raw time data, spectrograms, etc. / type of architectures proposed for multichannel noise reduction / UAV specific studies etc.) in order to propose a framework and an architecture for the development of these methods.
Then, considering that the features of the signal of interest must be extracted from the noise to reconstruct a cleaned signal, we move towards an encoder-decoder type architecture, which could constitute the generative part of a generative adversarial network whose discriminator would differentiate cleaned signals from real "silent" signals.
A study will then be devoted to the feasibility of implementing causal transformers integrated into the deep model. For the constitution of the database, a prototype drone will be available allowing the synchronous acquisition of data measured with on-board microphones and various flight parameters. An anechoic chamber and an outdoor experimental field are available for the experimental phase.
Participation in international congress and writing of scientific papers in a top-tier journal will be encouraged.

Candidate profile

Candidates (holding European citizenship) must hold a master's degree or engineering school with a major in computer science, signal processing, acoustics, or applied mathematics. Experience in machine learning and deep learning, in particular convolutional networks.
The candidate should have very good programming skills, with experience using the Pytorch or Tensorflow deep learning libraries. Good written and oral synthesis skills for the presentation of research work. Experience in writing an article would be a plus.

Academic advisor

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