Laboratory: Institut d’Alembert
University: Sorbonne University
Title of the thesis: Oceanic Acoustic Soundscape Identification System (OASIS)
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Collaborations within the thesis:
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This subject can be published on the doctoral school’s web site:

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Thesis’s summary (abstract):
Noise pollution in the oceans is currently a major concern. Several acoustic observatories have been set up to provide better information on the environmental state of the oceans. They are diverse types, permanent, semi-permanent and just dedicated for daily observations; they can be deployed on mobile platforms, such as gliders or robotic boats (Sailing Unmanned Vehicle), or on mounted stations at sea or near the coast.

Noise pollution, generated by human activities such as marine traffic, oil prospection and sonar, has direct impacts on the biodiversity of the oceans. These noises are part of underwater soundscapes. This study aims to identify the acoustic sources, to separate them, and to classify into 3 categories (biophony, geophony and anthrophony). It is thus a question of better characterizing the acoustic levels, the bandwidths and the types of sounds (impulsive or continuous) in order to create relevant and spatio-temporally dynamic noise maps. The second motivation is to be able to create predictive acoustic maps, based in particular on the estimation of the development of marine traffic and also taking into account technological advances, because some of them will contribute to reduce the acoustic power emitted by tankers and super-tankers. The third part is to collect acoustic data to describe the nature and level of impacts on marine life. All of these results will have to be integrated in an engineering solution in order to be used for managing human activities at sea.
Project OASIS

Objective: The objective of this PhD thesis will be to automatically describe underwater soundscapes. It includes the detection and the classification of sound events in acoustic recordings. A special attention will be done on anthropic sounds in order to estimate the environmental quality of the oceans.

Contexte: The anthropic sources that generate underwater sounds are numerous and diverse. The most predominant emissions are those from marine traffic, some military sonars, and geophysical prospections, the deployment and maintenance of offshore wind farms, harbour constructions and the loading/unloading of containers... Therefore, the acoustic density has continuously increased over the past few decades. For example, 90% of the good exchange passes through the seas. Supertankers are getting bigger and bigger, reaching 400m in length! This intense marine traffic generates low-frequency sounds which propagate very well in the oceans.

In France, underwater noise has been identified as pollution in the French policies since 2010. France is also very active at the international level to encourage better consideration of the impact of these anthropogenic sounds and encourage industries for mitigation. Similarly, in 2014, the International Maritime Organization published directives for shipowners to reduce underwater noises, for example, by detaching the engine from the boat’s hull to stop the sound transmission through the hull, or by using modern propellers that produce less cavitation.

To quantify the evolution of noise density in the marine environment, underwater observatories equipped with one or more hydrophones (waterproof microphones) have been deployed either near the coasts or at sea. Automatic analysis become necessary to process the 24/7 acoustic recordings. With these large databases, we first want to detect and classify the sound into 3 categories: geophony, biophony and anthropophony. The objective is to focus on the sounds from human activities, because several studies have shown that marine ecosystems are very sensitive to their pressures. Effects are more or less important for different species of fish, turtles, plankton, marine mammals, from simple disturbance to lethal consequences.

A PhD thesis cosupervised by Dr. Cazau, Ensta Bretagne, has already been carried out (2017-2020). Results were the design and the creation of a specific software to annotate the acoustic recordings. This software is open to the public that is interested by participatory science (for more info, visit https://osmose.xyz/).

Method: The current challenge for recent methods for detection and classification comes from the great diversity of acoustic recordings. Sound events are diverse, with different acoustic features, but also can be more or less masked by other sounds. The data acquisition also modifies the quality of the dataset. Over the past 2 decades, different bioacoustic criteria were defined, based on certain characteristics, either temporal or frequency, or resulting from mathematical methods. These descriptors are more or less effective, and the performance generally decreases quite quickly when the sounds of human activities are dominant. In addition, the massive amount of data makes analyzes more complex while requiring greater computing power.
Recently, the use of deep-learning is giving promising preliminary results. Currently, the difficulty lies mainly in the lack of previously annotated data. Also, in the team, we have developed a computer platform aimed at simplifying the annotation process, with the particular objective of offering it to the public in a participatory science approach. This initiative will allow more efficient use of supervised learning algorithms. In addition, we believe that a hybrid approach, relying on the use of multiple descriptors, will improve classification performance. The PhD thesis will aim to explicitly show this point.

The methods developed will be applied to different types of underwater acoustic recordings, in particular the datasets obtained from the International Workshop DCLDE.

**Expected results:** The first expected result is to propose a comprehensive approach that can be easily deployed on any type of underwater acoustic recordings. We need to consider the creation of a dynamic catalog of sounds and incremental learnings making it possible to adjust the classifications over time according to the recurring and innovative information inside the dataset.

As a 2nd result, we want to help describe the effects of human activities on marine ecosystems. To do this, it involves identifying modifications in ecosystems, changes in the behavior of certain species and making the link with the acoustic density of the area.

Finally, we want to offer software to provide indicators for experts in animal biology, marine ecology and managers of marine protected areas. This involves offering them a dashboard in which they can find all the information. This can be done from previous or actual acoustic recordings or also from predictive estimations; scenarios can be considered to anticipate any future changes in the environment.

**Références bibliographiques:**


