Acustica symposium 20 & 24 avril Lyon

Compilation of submissions for the session

“ Advances in Big data Bioacoustics : from sensors to deep learning “

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in the author list, we precise the registrated author by (*)

A) Section sensors and arrays for bioacoustics

1) JASON High Blue ultra high velocity recording : a big data Carabïan biodiversity survey
Gies, Glotin(*), Barchasz, Bernus, et al., SMIoT, LIS, Agence Fr. Biodiversité

The Agoa Sanctuary was established because of the abundance and diversity of cetacean species present in the waters of the French Caribbean islands. 24 of the world’s approximately 80 identified cetacean species have been observed here for now. There are enormous issues at stake across the Caribbean and internationally, to reconcile the protection of these resources and their promotion for the development of sustainable ecotourism business. The attraction of what is sometimes referred to as “blue gold” for sustainable tourism is very strong. In order to cover most of the frequencies of the present species, we designed a novel ultra high velocity recorder, called JASON High Blue (SR 512 kHz), with 40 days autonomy and low cost. Twenty of such systems have been built with EU Grant CARIMAM, and are deployed in january 2020 in a network of marine protected areas dedicated to marine mammal conservation in the Wider Caribbean region and beyond, yielding to 60 To of recording in 2020 and the largest international bioacoustic observatory.

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2) Azigram on stereo sonobuoy : 4 years tracking by Bombyx Port-Cros National Park
Glotin(*), Best, Poupard, Ferrari, LIS CNRS

The BOMBYX stereo sono buoy is a non expensive device that can derive azimuth and radial velocities with acoustic pressure. This information enables computation of azimuths of low-frequency and high acoustic sources from a compact sensor array. The standard approach for estimating azimuth from these antenna could be by conventional beamforming, but it is computationally expensive, and vulnerable to directional noise contamination for weak signals. We recall here the alternative multiplicative processing scheme that computes the “active intensity” of an acoustic signal to obtain the dominant directionality of a noise field as a function of time and frequency. This information is

conveniently displayed as an “azigram,” which is analogous to a spectrogram, but uses color to indicate azimuth instead of intensity. Data from Bombyx over 4 years demonstrate this approach. We illustrate how azigrams improves detectability of low signal-to-noise ratio signals and may also enhance the detection and potential classification of signals embedded in directional noise fields.

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3) Sphyrna Odyssey : a big data approach for 3D tracking and behaviour studies of deep divers
Poupard(*), Ferrari, Best, Gianni, Gies, Barchasz, De Varenne, Glotin, LIS, SMIoT, SeaProven

We present recent results of the Sphyrna Exploration composed of 2 ASV. We demonstrate that we obtain a high definition 3D track of deep diving cetaceans from a five-channel, small-aperture hydrophone array on our moving autonomous surface vehicle (ASV). The vessel’s hydrodynamic quality and the high recording sample rate allow detailed acoustic observations. Then we demonstrate detection and localization of the echolocation clicks of sperm whales. Resulting 3D tracks depict the behavior of the cetacean in the abyss (−1 km), with one position per second. This high resolution allows us to observe a correlation between the repetition rate of the predator’s biosonar and the tortuosity of its track (see : http://sphyrna-odyssey.com).

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4) Orca call tracking, large and short scales
Poupard(*), Best, Symond, Spong, Glotin, LIS CNRS, Orca Lab Vancouver CA

Killer whales (*Orcinus orca*) can produce 3 types of signals: clicks, whistles and vocalizations. This study focuses on Orca vocalizations from northern Vancouver Island (Hanson Island) where the NGO Orcalab developed a multi-hydrophone recording station to study Orcas. The acoustic station is composed of 5 hydrophones and extends over 50 km 2 of ocean. Since 2015 our team is continuously streaming the hydrophone signals, yielding nearly 50 TB of synchronous multichannel recordings. In joint abstract (Best et al.) we trained a Convolutional Neural Network (CNN) to detect Orca vocalizations, using transfer learning from a bird activity dataset. After detection, we cluster vocalizations by features describing the pitch contour, yielding to a mapping in time and space of the different Orca call patterns that we analyse joint to metadata (tides, moon phases…). We discuss on new insights on phonotactics and ethoacoustics of this endangered Orca populations by increasing anthropic pressure.

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B) Section Deep learning

5) Deep Learning of Adapted Wigner-Ville transform for fine time-frequency representation of clicks of cetaceans
Balestriero, Glotin(*), Rice univ USA and LIS CNRS Toulon

Time frequency representation and learning of bioacoustical clics are one of the most challenging due to some key challenges : a small perturbation of the representation of transient is the core of today's machine learning research.With the complexity of the signal growing, it becomes necessary to carefully choose or learn a representation space for the received signals, in which the information carried by them is discriminant. Furthermore, most challenges are specific to such dataset, making the use of Deep Networks (DNs) more intricate than for image data. In fact, most current state-of-the-art solutions employ first some a priori designed signal time-frequency representation which can then be seen as an image and fed into standard DNs. In this paper we propose a raw audio learning of optimal TF representation based on WV transform and optimised co-variance convolution to pool in time and / or in frequency the TF pixels. We give the theory and test on the College de France Challenge DOCC10 (to appear the 29 janvier 2020 in the ENS Data Challenge). Another application is given on Blue whale calls (Patris et al. in this session).

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6) End to end raw audio deep learning of clicks

Ferrari(*), Glotin, LIS CNRS

In this paper, we propose a raw audio deep learning of clicks, building specific convolution filters in high dimension to elaborate complex TF representation. The CNN has 12 layers for several thousands of audio bins in inputs, and a dozen of output classes. We test it on the international DCLDE challenge of 3 To of clicks (http://sabiod.org/DCLDE). This challenge was open in 2018, but no team answered before. At our knowledge, our model is the first raw audio click classifier with nearly 70% accurray on a dozen of classes.

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7) Autonomous Rainforest Soundscape Identification: Quantifying the impacts of Data Lossy Compression, Frame Size and Feature Selection

Becky Heath(*), Sarab Sethi, David Orme, Rob Ewers, Lorenzo Picinali

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8) Deep Learning Methods for Acoustic Monitoring of Birds Migrating at Night

Hanna Pamula(*), Agnieszka Pocha, Maciej Klaczynski

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C) Section Interdisciplinary approaches on bioacoustic massive data

9) Codas and tactile contacts from sperm whales off Mauritius Island

Yernaux, Adam, Sarano(*), Univ Paris 6 and Longitude 181

Complete and accurate observations of sperm whales' social activities (Physeter macrocephalus) are poor when they dive at deep depth, few in groups of males in cold waters, and scarce when adult or juvenile individuals are at the surface in breeding areas. Thanks to a set of underwater videos of sperm whales from one well known social unit, collected since 2013 in Mauritius Island (Indian Ocean) by MMCO, Longitude 181 and Label Bleu associations, we have been able to analyze 07h44min of videos, annotate 1321 patterned sequences of clicks, called codas, and study the existing links between these emitted codas and their social interactions. We also identified 32 individuals (18 adult females, 13 juveniles, and 1 adult male) and built a catalog of behaviors containing 21 behaviors. Our results show, 13 specific behaviors relative to 8 codas with different structures; associations that had never been done before. Besides, it appears that '8 clicks'-codas are the most recurrent ones for this clan of sperm whales, particularly one structure which we annotated as "2+1+1+1+1+1+1". Then we suggest that these codas and this specific structure might represent the vocal signature of the studied social unit. This work therefore gives opportunities for further scientific investigation to better describe sperm whales, their social structure and their inherent behaviors.

Keywords: sperm whale, behavior, click, coda

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10) Sperm whale cultural group study: a pluridisciplinary approach (Maubydick)

Girardet, Sarano F(*) Sarano V, Vitry, Preud'homme, Heuzey, Madon, Delfour, Glotin, Adam, Jung
Univ. Brest, MNHN, ISYEB, Univ Paris 6, LIS CNRS, MMCO, Label Bleu Production, Longitude 181

Sperm whales form one of the cultural species of the marine realm. The main cultural trait in sperm whale is the transmission of codas, whose specificity define vocal clans grouping different stable social groups.

We used a multidisciplinary approach to study sperm whales in the Indian Ocean near the Mauritius Island, in a project called Maubydick. Extensive field and lab work allowed to characterize and name all the individuals of a stable social group, to carefully study their social behaviors and relationships, to record and analyze their codas, and to sample sloughed skin fragments for genetic analysis.

Kin relationships are now elucidated in the social group studied, and codas are under study. Our aim is now to understand if genetics relationships influence coda transmissions between individuals, or if cultural transmission occurs between unrelated individuals.

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11) Click individual attribution by massive UW nearfield multihydrophone acquisition

Ferrari(*), Glotin, Sarano, Gies, Ricard, Asch, Glotin, LAMFA, Longitude 181, SMIoT, LIS

Passive acoustics allow us to study group of animals and obtain information that could not be gathered through other methods. In this paper we study a set of near-field audiovisual recordings of a sperm whale pod, acquired with our ultra high-frequency and small aperture antenna. We then demonstrate how TDoA and non linear solver yield to the localisation of nearly all the clicks. Such characterization of their vocalizations, correlated to individual identifications, opens avenue to possible acoustic individual signature.

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12) Acoustic monitoring of fin whales in feeding grounds : a CNN detector of "downsweeps"

Patris, Malige, Balestriero, Glotin(*) AMU LIS CNRS and Rice univ.

Frequency modulated sounds, called downsweeps, are a common emission to most of the rorquals *(Balaenoptera sp.)*. In the corpus we recorded in the North coast of Chile (continuous recording, 2*3 months), we demonstrate that fin whales are emitting this type of sound continuously, whereas they are not producing songs. However, these sounds are not easily characterised, since they can vary in frequency and duration. We present a new detector based on adaptive time-frequency decomposition of bioacoustic signal, based on our novel Adapted Wigner Ville (AWV) (see in this session Deep Learning of Adapted Wigner-Ville transform for fine time-frequency representation of clicks of cetaceans Balestriero, Glotin). We then describe phonotactic statistics and discuss towards possible usage of these outputs for biopopulation assessment. In sum, we propose to run species diarization between Blue, Fin and Sei whales (see also Ou et al. 2015) that are foraging in this area which is maybe the most biomass productive due to an upwelling of the Humboldt current coming from Antarctic to subtropic.