

An automated, real time classification system for biological and anthropogenic sounds from fixed ocean observatories

Serge Zaugg, Mike van der Schaar, Ludwig Houégnigan, Michel André

Laboratori d'Aplicacions Bioacústiques, Universitat Politècnica de Catalunya, 08800 Vilanova i la Geltrú, Espanya.
www.lab.upc.es

Abstract. *The automated, real time classification of acoustic events in the marine environment is an important tool to study anthropogenic sound pollution, marine mammals and for mitigating human activities that are potentially harmful. We present a real time classification system targeted at many important groups of acoustic events (clicks, buzzes, calls, whistles from several cetacean species, tonal and impulsive shipping noise and explosions). The achieved classification performance indicates that the system will be useful to pre-process the very large data volume that can be gathered during long term acoustic monitoring campaigns or to detect the presence of cetaceans in real time for mitigation.*

Keywords. *Signal processing, ocean acoustics, bioacoustics, ocean observatories*

INTRODUCTION

Passive acoustic monitoring (PAM) of the marine environment has important applications for the study and monitoring of marine mammals and to understand how anthropogenic sounds affect marine life. PAM can be implemented continuously and over extended time periods, thereby enabling the recording of large and representative datasets. However, PAM campaigns inevitably result in a high rate of audio data acquisition. This can be problematic when the data needs to be transmitted, stored and analysed.

In case of continuous and long term PAM from fixed ocean observatories, it is generally expected that long sections of the data stream may not contain any acoustic events of interest. It is then desirable to automatically identify the interesting sections of the data.

The automated detection of a particular acoustic event in the marine environment is challenging for many reasons: (1) The large baseline level of background noise reduces the ability to detect weak acoustic events with a reasonably small false positive rate. (2) The intensity and the spectrum of the background noise is generally variable over time periods of hours or even minutes due to changes in sea state or local anthropogenic activity. (3) The occurrence of non-targeted events may falsely trigger a detector or, conversely, suppress the detection

of a targeted event. (4) Targeted events such as cetacean vocalisations and sounds from shipping are very variable per se.

METHODS

The detection system is composed of two stages: The first stage, made of several detection algorithms, detects segments that contain acoustic events and tags them according to broad classes (e.g. low frequency impulses, ultrasonic impulses, short tonal sounds). The second stage, made of several classification algorithms, classifies events that have been detected in the first stage into more specific classes, which have practical relevance (e.g. impulsive ship noise, ultrasonic cetacean clicks, cetacean buzzes, whistles).

The accuracy of the system was assessed on a test data set that is representative of a diversity of situations that are expected at ocean observatories: It contains recordings from several geographic areas; impulsive, tonal and broadband ship-sounds; sounds from airguns/explosions; cetacean clicks, creaks and buzzes; cetacean whistles and calls; segments with only ambient background noise.

RESULTS

The first stage reliably tagged segments according to broad classes: short tonal sounds (whistles and calls of cetacean), constant tonal sounds (sounds produced by shipping), low frequency impulses (airgun, explosions), mid-frequency impulses (sperm whale clicks, impulsive ship noise), high frequency impulses (ultrasonic clicks from cetaceans, impulsive ship noise). The second stage reliably classified events that have been detected in the first stage into more specific classes. Mid and high frequency impulses were classified as sperm whale clicks, ultrasonic cetacean clicks and impulsive ship noise. Fast bursts of impulses (e.g. creaks, buzzes) were

identified. Fig. 1 shows how the system detects and classifies impulses.

ACKNOWLEDGEMENT

DISCUSSION

The palette of detected events is highly relevant when studying marine mammals and their interaction with anthropogenic noise. The detection system has been shown to work reliably under diverse and challenging situations expected during PAM campaigns at ocean observatories. This system will be useful to pre-process the very large data volume that can be gathered during long term acoustic monitoring campaigns or to detect the presence of cetaceans in real time to activate mitigation measures.

This project is funded under the European Commission contract FP6-2005-Global-4 - ESONET 036851-2. The LIDO consortium is formed by: Universitat Politècnica de Catalunya (UPC); Istituto Nazionale di Geofisica e Vulcanologia (INGV); Istituto Nazionale di Fisica Nucleare (INFN); Consejo Superior de Investigaciones Científicas (CSIC); Tecnomare; dBScale; Universidade de Lisboa (UL); Centro Interdisciplinare di Bioacustica e Ricerche Ambientali (CIBRA); Consiglio Nazionale delle Ricerche (CNR); Technische Universität Berlin (TUB); Zentrum für Marine Umweltwissenschaften (MARUM).

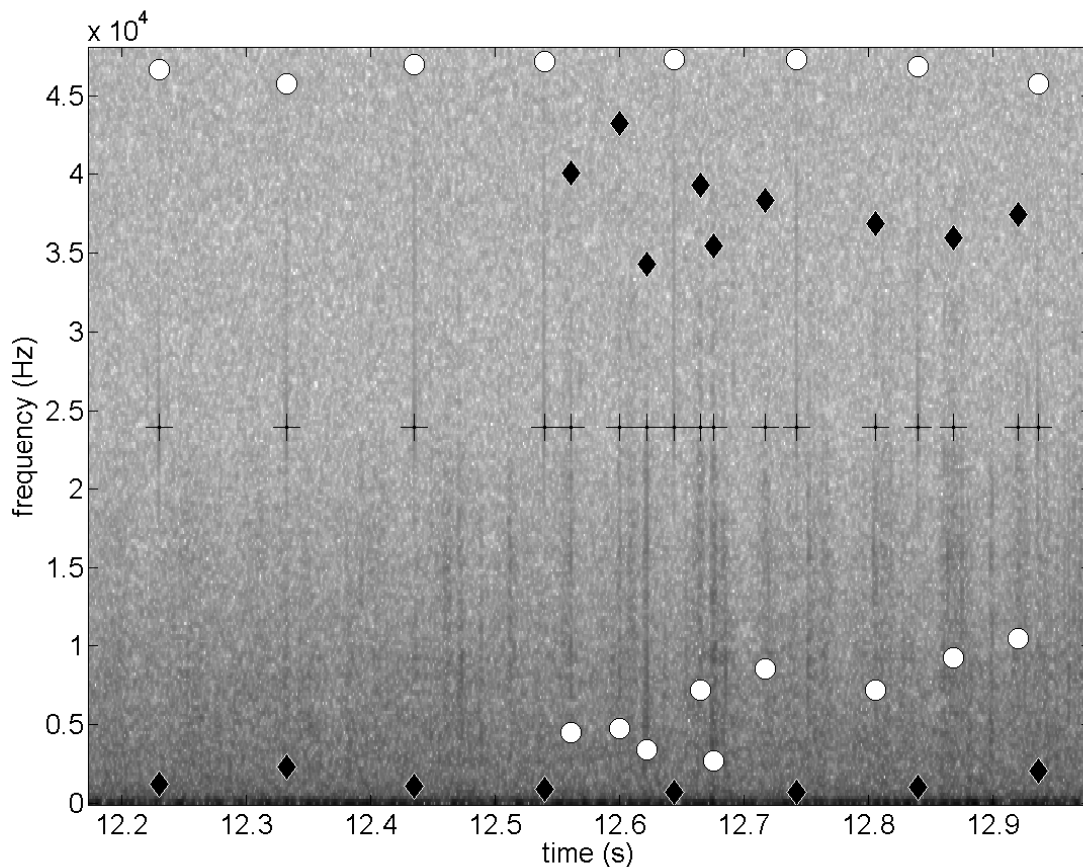


Fig. 1. Spectrogram of a segment with ultrasonic cetacean clicks (UCC) and impulsive ship noise (ISN). The detection of impulses in the band 20-46 kHz are plotted as black crosses (arbitrarily plotted at 24 kHz). At this stage UCC and ISN are confounded. The second stage classifier returns the estimated probability of being a UCC or ISN, plotted as white circles and black diamonds respectively (0 kHz: $p=0$, 48 kHz: $p=1$). By setting a threshold at $p=0.5$ the regular train of UCCs is separated from the ISN.