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NOISE CONTROL FOR A BETTER ENVIRONMENT

The impact of man-made noise on the passenger transport stations of Port of Barcelona

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ABSTRACT

Ports and harbours are logistic nodes characterized by several types of noise, which can usually occur in a concurrent manner in the same harbour premises: ferries, cruises, fishing and trade ships coexist with other industrial and auxiliary services. Noise pollution can have negative effects on the urban population inhabiting the port vicinity. The Port of Barcelona is an infrastructure that serves trade, passengers and fishing. The purpose of this work is to describe the impact of certain acoustic events recorded in the maritime stations of Port of Barcelona dedicated exclusively to passengers and vehicle transport. The traffic of arrivals and departures of cruises with passengers is intense in these maritime stations; the characterization of the acoustic events caused by this traffic, as well as the acoustic events collected by means of a short but complete recording campaign in Port of Barcelona. This work presents a proposal of categorization of the noise sources in order to generate an algorithm to classify automatically several types of activity.

Keywords: Noise, Environment, Port, L_{Aeq}
I-INCE Classification of Subject Number: 30

1. INTRODUCTION

Noise pollution derived from port activities is a source of annoyance for the citizens living in the surroundings, as well as it can have serious effects to health [1]. In this sense, several studies have addressed the present regulatory framework regarding ship noise both in air and in water [2], while several ports have already approved measures to manage the noise pollution in several locations [3], but these types of study are very environment-dependant.

Some analysis have already been conducted in the framework of the impact of port noise to residents in major ports. These studies have revealed that the continuous level of noise in the surroundings of the port affect the nearby area, together with road traffic

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noise pollution. We detail several studies in this line; in [4] the noise coming from the Piraeus (one of the most significant ports in the Mediterranean) is detailed together with the road traffic noise always with a special focus on the residents. In [5] a survey and several measurements of environmental noise have been conducted in the port of Tripoli, which in the framework of the MESP project activities, a survey about noise annoyance was conducted among port visitors, but also workers. In [6] the authors present the information system I^2 applied to the Port of Rotterdam; it helps to plan and manage the noise efficiently, because it supports tasks licensing, advises spatial development and the monitoring of complex noise situations in an industrialized are with large population in the surroundings.

Recently, research in the impact of noise has been centered in the association between road traffic noise and several diseases in suburban and urban areas. Öhrström states that the influence of road-traffic noise implies an increase in tiredness and disturbs the sleep [7]. Also, Botteldooren *et al.* analyze the influence of road traffic on noise annoyance in neighborhoods [8], while Jakovljevic *et al.* conclude that the most significant noise source in urban areas is road traffic noise, according to the interviewed residents [9].

The Port of Barcelona [10] has a strategic geographical location in the Mediterranean ($41^o21'$N, $2^o10'$E). It is an important logistic hub, influencing the social and economic development of its surroundings. It has thirty specialized terminals, with high level of diversification and specialization. Its operation is divided into several activities. On the one hand, it is the first port in Europe in terms of cruise activity, and on the other hand, it is a key distributor of energy goods and other types of cargo. In the aim of providing an analysis of the soundscape of the Port of Barcelona that could be of use for further research of possible future related services, this work presents a first step towards characterizing the type of founds sounds in this area. In [11], a first approach to the description of the noise sources in the Port of Barcelona was conducted; the detail of the number of samples recorded per noise source and the signal-to-noise-ratio (SNR) was described for the recording campaign. This paper details the conclusions of that recording campaign and proposes a classification of the types of sound, to face in the near future the design of an automatic detector of types of acoustic events [12] in order to generate a distribution of types of activity in each of the docks of the Port de Barcelona.

This paper is organized as follows. Section 2 details the information about the recording campaign in the Port of Barcelona. In Section 3 the dataset generation is detailed by means of a preliminary analysis of the spectral distribution and the impact of the noise events is performed, and Section 4 contains the spectral description and the preliminary impact analysis for several types of noise. Section 5 synthesizes the conclusions and the future lines of this work.

2. DESIGN OF A RECORDING CAMPAIGN IN THE PORT OF BARCELONA

The main goal of this recording campaign was to collect several samples of types of noise present in the Port of Barcelona in order to provide a general picture of its real-life soundscape. To that effect, during the 12th and 13th of January 2018, a total of four recordings were made across the Port of Barcelona, as shown in Figure 1. The four selected places were: Adossat dock terminals A and B, Contradic dock and Bosch&Alsina wharf.

The measurement device was a low-cost sensor [13] connected to a ZOOM H4n

Day	Location	Time	GPS
12.01.18	(1) Adossat dock terminal A	18:00	41º21'42"N 2º10'55"E
13.01.18	(2) Adossat dock terminal B	18:00	41º21'36"N 2º10'51"E
12.01.18	(3) Contradic dock	16:00	41º21'40"N 2º10'14"E
12.01.18	(4) Bosch&Alsina wharf	20:00	41º22'33"N 2º10'46"E

Table 1: Recording dates, times and locations.

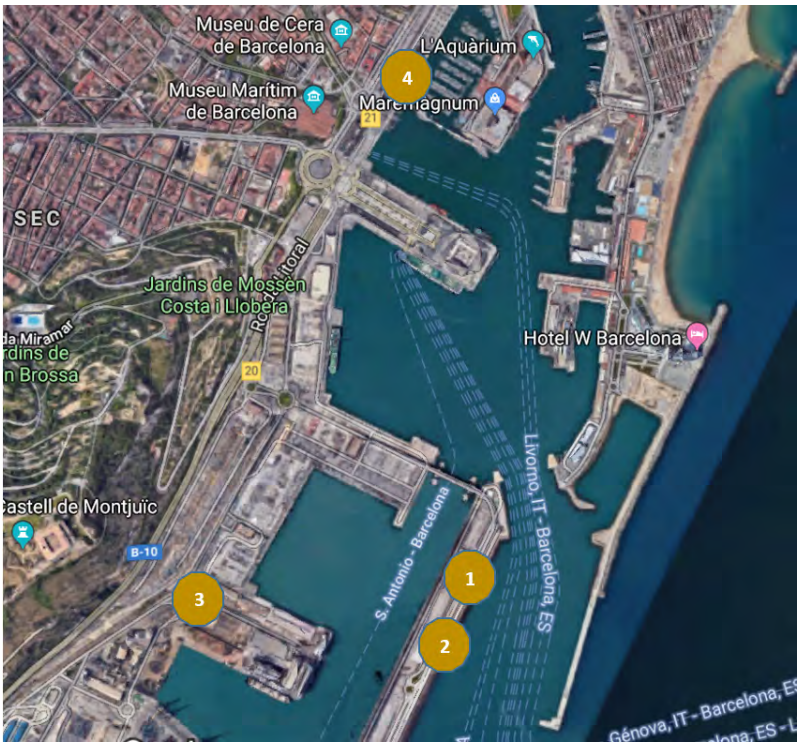

Figure 1: Recording locations in the port area of Barcelona.

digital recorder. The sampling rate was 48 kHz with 24 bits/sample; the sensitivity verification was conducted using a 94 dBSPL and 1 kHz calibration tone. The input gain of the recorder was selected to guarantee room for the in-site audio dynamics avoiding saturation. The measurements were conducted using elevation angles of 0^o in the direction of the main noise source (depending on the location). Another factor taken into account when setting up the measurement device was to be close enough to any potential low-noise events, while keeping a distance from any continuous, high-noise events that can mask other sounds, like a stationary truck with the engine on. Finally, the device recorded around 30 minutes for each location.

In Figure 1 the recording locations in the Port of Barcelona are shown. The locations in the port were chosen using two criteria: *i)* the availability of measuring (some places in the port have their access limited) and *ii)* the location close to noise sources (e.g. helicopters, cruises, etc).

Figures 2, 3, 4 and 5 show the recording setups for terminal A of Adossat dock, terminal B of Adossat dock, Contradic dock and Bosch&Alsina wharf, respectively.

Figure 2: Recording setup at terminal A of Adossat dock.

Figure 3: Recording setup at terminal B of Adossat dock.

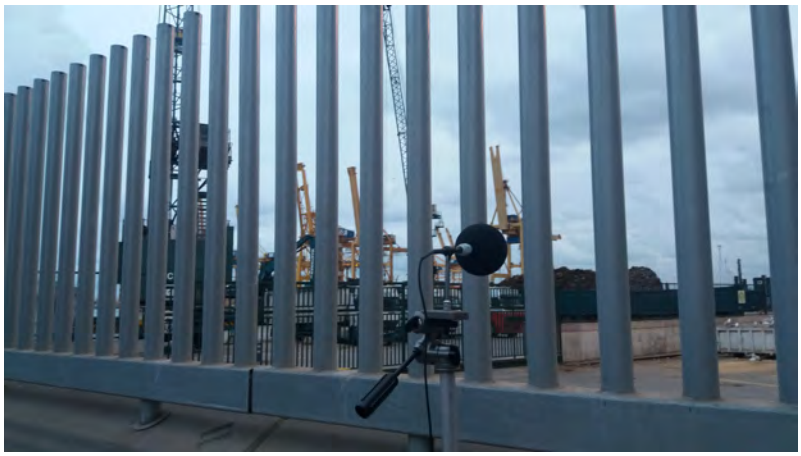

Figure 4: Recording setup at Contradic dock.

3. REAL-LIFE PORT ENVIRONMENTAL AUDIO DATASET GENERATION

In the generation of the dataset of the real-life port environmental noise, the noise events recorded have been annotated and labeled with the Audacity software, using standard four-letter codes related to noises which can found in the recording campaign

Figure 5: Recording setup at Bosch&Alsina wharf.

locations. After the analysis, those events were divided into 16 categories, a proof of the Port of Barcelona great diversity of sounds; specifically, the labels used and their meaning are:

- **acar**: car alarm.
- **brak**: braking sound of a vehicle.
- **busd**: opening bus or tramway door noise, or noise of pressurized air.
- **car**: car engine or wheels.
- **door**: noise of house or vehicle doors, or other object blows.
- **ferr**: ferry engine.
- **hcru**: cruise horns (usually three horns before they depart).
- **heli**: helicopter.
- **mbik**: motorbike engine and wheels.
- **peop**: people talking.
- **seag**: seagull birdsong.
- **sire**: siren (police cars, ambulances, etc).
- **skat**: skate or sounds of wheels over nonuniform surfaces.
- **step**: people walking.
- **trck**: noise when vehicles run over a bump.
- **truk**: truck engine or wheels.

3.3.1. Analysis of the Recording Locations

In the following sections we detail the setup used to conduct the recording campaign and the typology of noise events, as well as their length and duration for each recording location.

3.1.1 Adossat dock terminal A

Adossat dock is the main entrance for the arrival and departure of cruises (see Figure 1). All four terminals are connected by road (see Figure 2), therefore the recording captured not only boat noise but also traffic noise. The recordings show traffic noise due to the proximity of the road; another interesting contribution is the ferry sound, a single sample of more than 150 s, as the boat was entering the dock very slowly while the recording was conducted.

3.1.2 Adossat dock terminal B

Adossat dock terminal B is located about one hundred meters from terminal A (see Figure 1), so the measurements in both locations show similar results. Besides road traffic noise, which is common in both terminals, in terminal B the microphone captured several helicopter noise, mainly devoted to tourism.

In Figure 3, the recording setup for terminal B in Adossat dock is shown. In terminal B the longer noise events correspond to helicopter noise, followed by the traffic noise coming from trucks and cars. The other sounds show both short duration and also short accumulated audio recorded in that location.

3.1.3 Contradic dock

The Contradic dock is a restricted area, with cranes used to load and unload the cargo of the ships. Even though the microphone was set far from the working area, several sound events coming from Contradic dock could be recorded. The two sounds that are clearly more prominent than the others are trucks for package transporting and the seagull birdsong, because it is close to the fishboat part of the Port. Figure 4 shows the recording setup for Contradic dock area, where the data collected presents maximums in seagull birdsong and road traffic noise coming from cars and trucks. These results are so large that also present maximums in the aggregated values of recorded audios.

3.1.4 Bosch&Alsina wharf

Bosch&Alsina wharf is a tourist area with docked boats and pathways where people stroll. Figure 5 is a picture of the recording setup for the measurements in Bosch&Alsina wharf. In this wharf, the noise coming from people is more predominant than in the other docks. People talking, skaters and steps are some of the most usual sounds, together with sirens and doors. This place corresponds to the soundscape of city life more than port life, probably because the dock is devoted mainly to tourism.

3.3.2. Aggregated Results for the Port of Barcelona

From the point of view of all aggregated results, as shown in Figure 7 and in Table 2, cars and trucks are by far the most common event recorded due to its high frequency of appearance, followed by ferries, helicopters and seagulls. All the information regarding the exact number for each event are displayed in Table 2, sorted by event and location. Besides, each event has its own duration distribution (see Figure 6) and it has to be taken into account when choosing which events are more relevant; for instance, an helicopter sound can last for over a minute, while a seagull birdsong has a duration of around a second.

Event	Ter.A	Ter.B	Contr.	B&A	Total
acar	0	1	0	0	1
brak	0	0	1	0	1
busd	4	0	2	0	6
car	47	22	6	0	75
door	0	0	3	15	18
ferr	1	0	0	0	1
hcru	3	0	0	0	3
heli	0	3	0	0	3
mbik	5	1	0	1	7
peop	2	1	0	27	30
seag	1	0	68	7	76
sire	0	0	0	1	1
skat	0	0	0	5	5
step	0	0	0	2	2
trck	3	5	0	0	8
truk	13	4	2	0	19

Table 2: Number of noise event per location.

All in all, Port of Barcelona have a wide range of noise events, where some types are more likely to appear depending on the location. In the dock terminals, the most common are vehicles and ships like ferries and cruises; in Contradic dock, we mainly find trucks and seagulls; and in the tourist wharf, people chatting is the most regular sound.

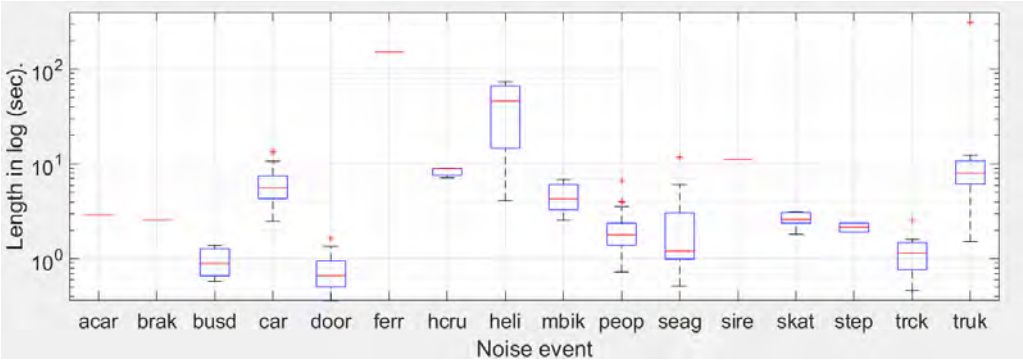

Figure 6: Total labelled events and their lengths of the recording campaign at Port of Barcelona.

4. SOUND CATEGORIES FOR THE PORT OF BARCELONA

The recording campaign and its subsequent analysis have presented the results from different points of view. On the one hand, it has become clear that in each dock there is a predominant activity - cruises, tourism, cargo ships, etc. - but that this does not limit the fact that in each measured location there is a heterogeneous combination of sounds. In order to be able to advance in the study and to be able to order the predominant type of activity appropriately, but also to be able to detect secondary activities, it would be desirable to be able to automate the detection of sound types. With this aim, we have

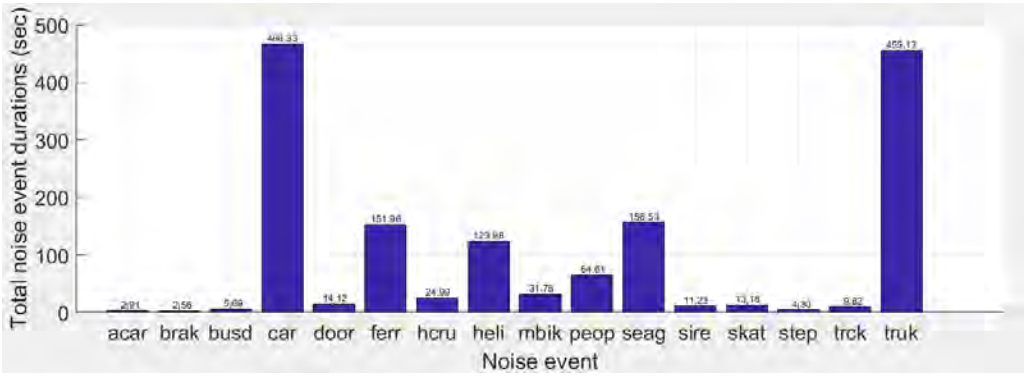

Figure 7: Total labelled events and their aggregated duration of the recording campaign at Port of Barcelona.

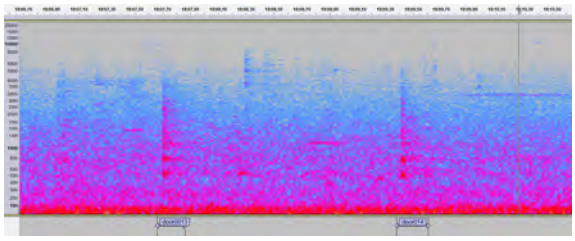

Figure 8: Door closing noise.

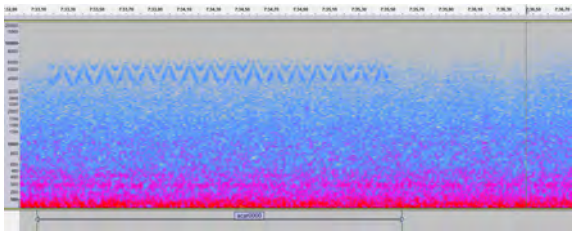

Figure 9: Car alarm noise.

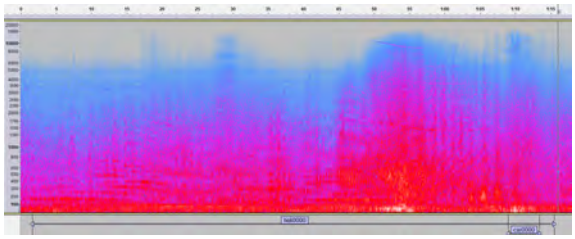

Figure 10: Helicopter noise.

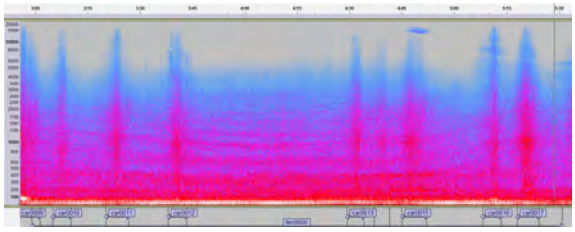

Figure 11: Ferry noise.

grouped the types of sound found into four categories: one that refers to the noise of ships, another airborne noise, road traffic noise and finally, noise generated by man or animals. There were several classification options, from the most analytical - where we could have classified according to the spectral distribution we see in the different noises (see figures 8, 9, 10 and 11- but a distribution based on the application has been preferred, much closer to the use case to be implemented.

The final classification can be seen in the table 3; comment that airborne noise is practically exclusive to helicopters in the port, but that it has a high impact on the noise level. Noises generated by man or animals are very varied, but in general have a low impact on the background level. The two most relevant noises are marine traffic and road traffic, and they are probably also the most interesting to differentiate with respect to their impact on people. This classification makes it clear that, in order to train a classifier, the measurement campaign will probably have to be expanded, since the four classes have not been balanced in terms of the amount of data for subsequent training.

Sea Traffic Noise	**Road Traffic Noise**	**Air Traffic Noise**	**Person/Bird Made Noise**
ferr	acar	heli	door
hcru	brak		peop
	busd		seag
	car		skat
	mbik		step
	sire		
	trck		
	truk		

Table 3: Categories defined for the recording campaign of Port de Barcelona.

5. CONCLUSIONS

This paper described a recording campaign in the Port of Barcelona, in four different locations, strategically chosen to have a diversity of sounds in the analysis. The result of this work focuses on the generation of a port noise dataset, manually labeled, which also allows us to describe the existing soundscape in the Port of Barcelona. Finally, a first preliminary categorization for the different types of sound encountered is presented, with four categories: sea traffic noise, road traffic noise, air traffic noise and person and animal noise. The four categories are not balanced in the number of different types of event nor the total amount of data collected. For this reason, future work will observe to expand the recording campaign to complete certain groups, in order to have a balanced dataset to train a multiclass algorithm to detect each type of noise in a real-operation environment in the Port de Barcelona.

6. ACKNOWLEDGEMENTS

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