



UNIVERSIDADE CATÓLICA PORTUGUESA

Composing with Soundscapes

Capturing and Analysing Urban Audio for a Raw Musical Interpretation

Thesis submitted to the Portuguese Catholic University for the Doctoral
Degree in Science and Technologies of the Arts - Computer Music

by

José Alberto Gomes

SCHOOL OF THE ARTS
April 2015



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Dissertation supervised by Prof. Doutor Álvaro Mendes Barbosa and
co-supervised by Doutor Rui Luís Nogueira Penha.

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This Doctorate Research was partially supported by the Portuguese Science and Technology Foundation (FCT), through the award of the Doctorate Grant reference SFRH/BD/71405/2010.



Abstract

The sound environment is increasingly more relevant in contemporary culture. It is a 'picture' of a place, an X-ray of its character and activities, shapeless and amorphous, whilst full of meanings and subtleties. It is a transmission that is complementary to what a picture retains and transports. Therefore it is a unique, tangible impression of the place to which it belongs, and intrinsically, its history, and that of the people who inhabit it, and their relations. Murray Schafer termed this element as Soundscape. Although always a present element, it was only from the end of the Twentieth Century that it has been studied in a systematic way, initially in a more ecological and socio-cultural function approach, but slowly it has been seen as an artistic tool, both in direct use of the sounds as well as being an inspiration, and a starting point, for creation. The exploratory research project presented here aims to study the capture and analysis of the urban soundscape, with a special focus on its temporal evolution, and its application in the creative and artistic context. At the first stage, we try to understand how and, if possible, to capture and represent the most challenging part of this massive sound element, which is its constant changing on the time axis. Grasping its nuances on both small and large time scales. The second phase is to understand the pertinence of such information and its direct influence in the act of music and sonic creation. To achieve these goals a multidisciplinary approach based on two main pillars was necessary: Soundscape and Computer Music. These disciplines determine the scientific areas in which this research had to be focused. Due to the fact that this thesis has a relatively broad scope of interests, there is a survey of the state of the art relating to projects and approaches that relate to the interests of this investigation in different ways. In areas such as: *Music Information Retrieval*, Algorithmic Composition, Eco Composition, and Sound Maps. This survey confirms the contemporaneity, relevance and originality of the project, both scientifically and artistically.

In order to evaluate the proposed approach to the soundscape, URB, an experimental system to capture, analyse and store the urban soundscape was developed and implemented. The system is based on current technology, but is affordable and robust. To ensure the sustainability of the project, development was based in open source technology, to ensure the possibility of the project expanding and shaping according to the interests and needs of specific places, populations, research centres and/or artistic interests. Three main goals have guided the development of this system: addressing the lack of temporal perspective of the sound representation of urban spaces; the design of a free and autonomous system that depends only on the users, which results in a public free access database; to facilitate and systematize the access to data on the sound characteristics of an urban soundscape for both ecological studies as well as for creative and artistic purposes. A server keeps a record of the collected data, which can either be read directly, through an application developed for this purpose, or through a visual interface with a time-line approach, but always allowing for the possibility of creating original access tools that best serve the user's purposes. After implementing the system, through four listening points, and confirming its robustness, we advance to the system's application in the development of artistic works. For this purpose a challenge was proposed to a number of artists with distinct aesthetic backgrounds and training. This challenge resulted in different works that were presented to the public in different formats and media, such as works for classical instrumental, electro-acoustic works, improvisational moments with real-time sonification of the soundscape, sonic installations and sculptures powered by the system presented. This practice leads to a fundamental

reflection in this research. We describe the different approaches chosen by each creator and primarily assess the pertinence in the artistic result of using a continuous and discrete system of urban soundscape analysis, from a creator's point of view as well as from a listener's point of view.

With this research we are able to present a functional approach to the lack of temporal perspective in the usual sound maps that focus on the geographic origin of the recordings. We conclude that soundscapes can provide useful data for artistic creation and we promote a direct connection between that kind of approach and the artists. Even before the works developed and the artist's feedback, whilst not ignoring the different approaches and opinions, we can conclude that this approach seems to promote new and functional soundscape composition ideas, making URB a relevant resource to compose original soundscape based music. Also, through analysis of the pieces, we could point out patterns of the technical and artistic choices on how to deal with information from the soundscape data, both in deferred time and real-time.

Resumo

A paisagem sonora é cada vez mais relevante na cultura contemporânea. É uma ‘fotografia’ de um lugar. Uma radiografia ao seu carácter e atividades, simultaneamente disforme e amorfa como repleta de significados e subtilezas. Uma transmissão complementar ao que a imagem retém e transporta. É portanto uma impressão única, tangível do lugar a que pertence e, intrinsecamente, da sua história, das pessoas que o habitam, das suas relações. Murray Schafer batizou este elemento como Soundscape (Paisagem Sonora). E embora tenha sido sempre um elemento presente, só a partir do final do séc. XX é que tem vindo a ser estudado de uma forma sistematizada, inicialmente numa abordagem mais ecológica e das suas funções socioculturais, mas lentamente encarado como uma ferramenta artística tanto no uso direto dos sons, como sendo o ponto de partida de inspiração para a criação. O projeto de investigação de carácter exploratório que aqui apresentamos visa o estudo da recolha e análise da paisagem sonora urbana, com especial enfoque na sua evolução temporal e da sua aplicação no contexto criativo artística. Como tal, numa fase inicial, procurar entender como e, se possível, capturar e representar o elemento mais desafiante que é a permanente mutação sonora no eixo temporal, apreendendo as suas nuances tanto numa escala de tempo diminuta como em grandes escalas temporais. Numa segunda fase entender a pertinência desta informação e da sua influência direta no ato da criação musical e sonora. Para cumprir estes objectivos foi necessária uma abordagem multidisciplinar fundamentada em dois pilares principais: Paisagem-Sonora e Informática Musical. Estas disciplinas determinam as áreas científicas em que esta investigação se debruçou. Tendo esta tese um âmbito de interesses relativamente amplo, há um levantamento do estado da arte referente a projetos e abordagens de áreas distintas que, de diferentes formas, se relaciona com os interesses da nossa investigação. Em áreas como: *Musical Information Retrieval*, Composição Algorítmica, Eco Composição, Mapas Sonoros. Este levantamento confirma a atualidade, a pertinência e a originalidade do projeto, tanto cientificamente como artisticamente.

A fim de avaliar a abordagem proposta à paisagem sonora, foi desenvolvido e posto em prática um sistema experimental de captura, análise e armazenamento de ambiente sonoro urbano, de nome URB. Sistema esse baseado em tecnologia atual, mas acessível e robusta para garantir a sustentabilidade do projeto e apoiado em desenvolvimento código aberto para garantir a possibilidade do projeto se expandir e se moldar de acordo com os interesses e necessidades concretas de locais, populações, centros de investigação e interesses artísticos. Três objetivos principais guiaram o desenvolvimento deste sistema: colmatar a falta de perspectiva temporal em grande escala de uma representação sonora de um espaço urbano; o desenho de um sistema que livre e autónomo, que apenas dependa dos utilizadores, que resulte numa base de dados de acesso público e gratuito; facilitar e sistematizar o acesso à informação sobre as características sonoras de um ambiente sonoro urbano tanto para estudos ecológicos como para função criativa e artística. É mantido num servidor o registo de toda a informação recolhida, que tanto pode ser consultado diretamente, através de uma aplicação desenvolvida para o efeito, através de um interface visual ao estilo de linha temporal, deixando sempre a possibilidade para a criação de ferramentas de acesso originais que sirvam melhor os propósitos do utilizador. Após a implementação do sistema, através de quatro pontos de escuta, e a confirmação da sua robustez, avançamos para a aplicação do sistema no desenvolvimento de obras artísticas. Para tal, foi lançado um desafio a um conjunto de artistas que partem de diferentes formações e identidades estéticos. Esse desafio

resultou em diferentes obras que foram apresentadas ao público com diferentes formatos e suportes, como obras integralmente para formatos instrumentais clássicos, obras electroacústicas, momentos de improvisação em tempo real com a sonorização do ambiente sonoro, instalações e esculturas sonoras alimentadas pelo sistema apresentado. Desta prática resulta uma reflexão fundamental nesta investigação. Descrevemos as diferentes abordagens escolhidas por cada criador e acima de tudo avaliamos a pertinência no resultado artístico do uso de um sistema contínuo e discreto de análise de ambiente sonoro urbano, tanto do ponto de vista do criador como do ponto de vista do ouvinte.

A partir desta investigação, apresentamos uma abordagem funcional para a falta de perspectiva temporal nos mapas sonoros clássico que incidem principalmente sobre as origens geográfica das gravações. Concluimos que as paisagens sonoras podem fornecer dados úteis para a criação artística e promover uma conexão direta entre essa abordagem e os artistas. Perante os trabalhos e análises desenvolvidos por diferentes criadores, concluimos que esta aproximação promove ideias novas e funcionais para a composição. Além disso, através da análise de peças, apontamos padrões nas escolhas técnicas e estéticas sobre como lidar com as informações a partir dos dados da paisagem sonora, tanto em tempo diferido como em tempo real.

Acknowledgments

To my supervisor, Doctor Álvaro Barbosa, for all confidence, support and freedom that he gave me to pursue my goals and for the insightful contribution to my own thinking in this area. To Doctor Rui Penha, my co-adviser, for his incredible availability and thoroughness, and for being a guidance both in scientific and artistic fields. Their kindness in helping, guiding and clarifying me through this adventure is deeply appreciated.

To the other PhD students enrolled in the Doctoral Program of Science and Technology of The Arts in particular, André Baltazar, André Perrotta, Joana Gomes, Samuel Van Ransbeeck, Vasco Carvalho, and Mailis Rodrigues for their help, feedback and ideas.

Special thanks to Diogo Tudela for setting up the MySQL database and his precious help with UNIX, Pitton and Java Script, and João Cordeiro, for being more than a colleague, a friend and a beacon, with ideas, guidance and encouragement, and latter for his hospitality during my time at São Joseph University – Macau.

A very special thank you for Filipe Lopes, Rui Dias, Gustavo Costa, Nuno Peixoto de Pinho, Diogo Tudela, Eduardo Magalhães, Luís Fernandes and Miguel Pedro for their participation with their art. Their altruistic participation and belief in my ideas were fundamental to the conclusions of this thesis. It was a pleasure and an honor.

Thank you to Sonoscopia Associação Cultural and Digitópia to embrace the artistic part of this project, and André Covas for letting me use his home to install the first URB-box.

To my long-term employer, Educational Department of Casa da Música Foundation for all their support in facilitating and encouraging this work, namely Director Jorge Prendas, who was always diligent in accommodating my schedules and obligations to my research.

To Doctor Carlos Guedes for introducing me, in 2004, to this amazing world of music, composition and computation. Without his guidance this thesis and most of my work would not be possible.

Last, but not less important, I would like to thank my nuclear family for all the patience and unconditional support, in particular my parents Maria Alzira and Humberto, and my sister Mariana who, besides the support, contributed with an infinite good taste to posters, presentations and pagination of this same thesis.

I want to thank my friend and partner Sofia for her affection, for putting up with all my moods arising from the writing of this thesis and to all my friends who have been constantly there for me.

To the grant institution, Fundação para a Ciência e a Tecnologia, Portugal, grant number SFRH/BD/71405/2010, whose gracious and steady financial support made this endeavor possible.

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Chapter 1

Introduction

The human presence has conditioned the world in a way and with repercussions that are very hard to evaluate, and the exercise of imagining a planet without any human interference could lead us to an enormous journey of possibilities and situations. But the fact is that humankind and its relation to everything that surrounds it, marks and represents a very interesting matter to study.

Humans are naturally inclined to exist in society, to develop relationships, to work, to live together. This necessity pushes it to organize itself in groups and to find hierarchies and structures. Obviously this development has more consequences than only the social relations, organizations and adaptations. Humans had to arrange large spaces to live together with specific characteristics to fulfil their necessities. This evolution was not always simple or peaceful. Most of the times it was a trial and error process to achieve models that were good enough. However this process is infinite and the characteristics of these groups are in perpetual mutation. One thing though, was coherent: these groups became increasingly larger and larger and the needs of the surrounding environment have become increasingly demanding. In this process densely populated areas slowly appeared. *A built-up area with a name, defined boundaries, and local government. (...) Especially as contrasted with the country or suburbs*¹. These areas not only represent social structure but naturally represent a major difference to the landscape in comparison to the countryside areas and to the wild nature.

This dissertation subject material is about a consequent element of this social and geographic areas: the urban soundscape, the way to capture and represent it, and a possible relation with creativity and art. This dissertation - Composing with Soundscapes: Capturing and Analysing Urban Audio for a Raw Data Musical Interpretation - has two different points:

1. Capture and Analysis of an Urban Audio Environment, is directly related to an ecological point of view. It is rather simpler to understand than the visual transformation between a wild landscape to an urban one, between two cities, between today and last year's landscape of the same city, and we can stretch that time range, because it is easy to resort to pictures or paintings. With soundscapes² however, it is not quite the same. It is not so simple to describe the difference between the sound of today and last year's sound and if we are going to increase that gap it is going to be harder and harder. If we go back in time more than 50 years, in most of the cases we can only rely on indirect sources and most of the time they are not very precise or have a great deal of subjectivity. There is a big difference between our ears and eyes. The eyes we can close. So we can decide to stop seeing. But we can not close our ears. So sound is always there. Our degree of awareness is very different. We are "programed" to respond to a siren or an alarm or to any sound signal that stands out from the background sound. But we are less prepared to be conscious of the evolution and the transformations that background over time, mostly because

¹ "town". Oxford Dictionaries. Oxford University Press

² During this thesis Soundscape, capitalized, refers to the ecological, artistic and scientific movement, and soundscape, with lowercase, to a concrete sound environment.

it is always there. There are two different reasons for this: one is that the human being has more developed vision perception than the hearing perception and it is the main sense related to the surrounding reality. As an example, for the majority of humans it is easier to recognize faces than voices, and that is probably the reason why the car manufacturers generally spend more time and resources into make a car look nicer than to sound better; the second is that sound's "canvas" is time, and this is a major a problem. You can go to the top of the hill and take a picture to the city, a picture only needs an instant, but with sound it is different. What is a picture of a soundscape? An instant of a sound represents nothing. You need a larger window of time to represent the sound. How large should that window be? So it is harder to represent and to capture the sound part of a place. In this investigation we work on these problems.

2. As a Source Material to Music Creation. "No man is an island /Entire of itself /Every man is a piece of the continent /A part of the main (...)"³ In this famous poem by John Donne it is very well described as a human is part of something beyond itself, it is not born and does not die only in itself. It transforms and affects what surrounds it and the opposite is also verified. What surrounds us is an important element that defines us, either by contagion, by resistance or in extreme cases by cancellation So the same man today may not be the same as if he was born in a different era or area. So starting with this premise, how does the environmental sound transform a man, the art works being a crystallization of a time and space, how does the environmental sound affect his work? This investigation works on this subject in a way of how, and if it is important, to approximate the soundscape and the creator. After the capture and analysis of an urban sound system has been worked we "offer" it to the art community. The final part of this investigation is to study and to propose an artistic approach, to compare the results between them and also to analyse the feedback and opinions from the authors and peers. Finally, we try to conclude the relevance of this approach to soundscape as a gigantic sensor to be used in artwork.

To conclude, the present dissertation connects two key subjects - Soundscapes and Music Creation - with the purpose of presenting an innovative framework for urban sound researchers and sound artists based on the approach to the soundscape in a time based system.

1.1 Motivation

The youth has been completely conquered by this electronic world that is acoustic, intuitive, "holistic", this is, global and total, a new world that put on the shelf of the old scientific world with its quantities, its immensities,

³ "No Man Is An Island" poem by John Donne

our super-industrialized ‘First World’. The youth prefers the Third World because it is still acoustic and oral, and invites to total immersion (...) (Babin & M. McLuhan, 1978, p.191)

According to McLuhan’s critical thought, the 60’s and 70’s electronic revolution marked the return of the ear as a sovereign organ for cultural human perception. This sociocultural transformation underlined the Western man’s necessity of constant absorption. It is within this framework that the soundscape studies become more systematic and its presence as an artistic tool more persistent. This was not a new subject, but rather a new one that found fresh stable grounds within the constant multidirectional cultural and ecological awareness that dictates the Electronic Era. The notion of soundscape is increasingly relevant not only in contemporary culture and acoustic ecology, but also in many other fields, such as artistic production.

The first time that this topic caught my attention was in 2006 when I read this passage for the first time:

We are also disadvantaged in the pursuit of a historical perspective. While we may have numerous photographs taken at different times, and before them drawings and maps to show us how a scene changed over the ages we must make inferences as to the changes of the soundspace. We may know exactly how many new buildings went up in a given area in a decade or how the population has risen, but we do not know by how many decibels the ambient noise level may have risen for a comparable period of time. More than this, sounds may alter or disappear with scarcely a comment even from the most sensitive of historians. Thus, while we may utilize the techniques of modern recording and analysis to study contemporary soundscapes, for the foundation of historical perspectives, we will have to turn to eyewitness accounts from literature and mythology, as well as to anthropological and historical records. (Schafer, 1993, p.8)

Apart from my academic artistic evolution and development, that passage insisted on appearing in my mind. Even so, the opportunity or how it might be related to my work never appeared.

This thesis, embedded in the Computer Music area, appears with the will to find new mechanisms to turn to the soundscapes as a source to relevant artistic creations. Due to this, the investigation appears not only as a continuation of the work already done, but also as a new artistic interpretation to the sound material that surrounds us and in what way it can, directly, influence music creation.

The first main subject was in what way we can contribute to the already well-developed Soundscapes community in the capture and cataloguing of environmental sound. Usually the sound maps are based on a Google-style map that is used to situate the geographic origin of the recordings, e.g. World Listening Project⁴. However, as Barry Truax indicates, lacking any coherent temporal perspective:

Sound maps have become increasingly common on the Internet, where instead of files organized by subject matter (or not at all), a Google-style map is used to situate the geographic origin of the recordings (e.g. www.

⁴ www.worldlisteningproject.org

worldlisteningproject.org). I have found that the sound map is useful to orient people who are unfamiliar with the soundscape concept to the idea that soundscape recordings are markers of place. However, lacking any coherent temporal perspective, and usually lacking any interpretative analysis, the listener is left trying to imagine what has been recorded and what significance it has. (Truax, 2012, p.11)

This becomes our main subject, to work and become clear that it could be a very important contribution to the Soundscapes area of investigation. So we developed a system called URB, creating a database accessible to the public, from a permanent analysis of the environmental sound of a great urban space.

The second subject was, if relevant, to promote a direct connection between that kind of approach to the soundscape. So we conclude that we could contribute; systematize the information from the database, to be the basis for different artistic musical works, both in real and non real-time. In the last instance the better way to validate that approach was to promote a situation that different music creators, apart this investigation, apply this approach to the system and help us to conclude its pertinence.

1.2 Objectives of this Dissertation

The urban soundscape is probably one of the most present elements in our everyday life but simultaneously the one that we are least conscious of. Studies in the sound ecology field have been developed working on the capture and analysis of the soundscape field about its characteristics, evolution and repercussions. It is common sense that what surrounds us, in one way or another, is an influence on us and naturally on our artistic results too.

As such the objective of this dissertation is to contribute to the fields of Sound and Music Computing and Soundscape by:

1

- Presenting and studying knowledge of projects, models and theories proposed in the literature of soundscape analysis;
- Presenting and studying knowledge of the relation between soundscape and music creation;

2

- Pointing out new forms of capture and storage of an urban soundscape;
- Pointing out new methodologies for the analysis of soundscape characteristics in real time;

3

- Developing a model of an autonomous system (hardware and software) that captures, analyses and stores a urban soundscape;
- Creating a public database with the a local urban soundscape analysis;

- Promoting conditions of accessibility, interpretation and use of the database content;
- Leaving a model that can be applied in other cities, or other spaces, that can be expanded in a more complex design and can be applied and used by artists and other areas of interest;

4

- Disseminating and presenting the scientific and artistic work produced from these new approaches to the soundscape in music creation;
- Eliciting the production of knowledge and innovation in the field of the relationship between the soundscape, music creation and sound art;
- Pointing towards new approaches to create music from an urban soundscape.

1.3 Methodology Overview

In this sub-chapter we present an overview of our research design, listing and describing the most relevant steps that led to the conclusion of this project.

1. Formulation of the research problem.

During the first year of research I came across with the assumption by Barry Truax, presented earlier, about the lack of coherent temporal perspective of the typical sound maps (Truax, 2012). It seemed to be the perfect opportunity to relate the soundscape issue with my musical and artistic interests. Throughout the rest of the research year, the topic experienced its maturation process, being iteratively discussed with colleagues, as well as the confirmation of relevance of the issue having been reinforced by the advisor. Finally submitted to the scientific council with the topic Composing with Soundscapes: Capturing and Analysing Urban Audio for a Raw Data Musical Interpretation.

2. Extensive literature review.

The first two years were dedicated to literature review and state-of-the-art research, which encompassed the main areas of Soundscapes and Music Creation and with related areas like music information retrieval, Eco-Structuralism and Algorithmic Composition.

3. Preliminary Research Experiments.

In order to ground our main research, we developed four experiences with different uses of soundscapes in sound art creation. Those four pieces were been presented in public and were fundamental to understand and point out what problems we should approach to design a new soundscape capture and analysis system with potential use in artistic creation.

4. Prototype formulation

After a good understanding of the theoretical and artistic background, we draw a theoretical system and started to experiment with several options, software and hardware, until stabilizing in the final

design. That system was called URB.

5. Experimental research project

The chosen approach was based on empirical research and consisted in the development of a proof-of-concept system (software and hardware to the soundscape capture, database to store the information, and software to access the database) to assess the validity of the initial two issues – how to approach the absence of time perspective in the regular sound maps and how the environmental sound is able to directly catalyse music creation. Four listening points (the micro computer to capture and analyse the sound) were disposed in different places of downtown Porto. Those points were collecting the data, filling in the database with the history of the soundscape since the moment they were on.

6. Artistic application

The data collected and the software developed to access it, was published on a website created exclusively for it. A group of artists from different areas and backgrounds were then invited to work with the database in their musical work and to present the results in public venues.

7. Description and analyses

The artistic works were analysed and the approaches and processes described in detail. Firstly, a individual point of view, and secondly, comparing the processes and individual opinions with the aim of finding mutual elements and to understand the relevance of the project.

8. Discussion of the results

This thesis represents the outcome of the whole research, whilst being the main support of the description and representation of the entire process. It also has a fundamental and valuable critical analysis, the main conclusions and thus pointing towards the future directions of the project.

1.4 Main Challenges

Throughout the research we came across problems, challenges and situations that sometimes put us in a state of despair. Invariably though, each challenge was an opportunity that made us evaluate an mature as researchers and artists. With planning most of the problems were expected, and therefore welcome, but others appeared requiring an unexpected amount of time and attention, but it was exactly those situations that we now recognized that made this research what it is now. The challenges made us turn to solutions and approaches that we never thought of initially, and just going through that process is what permitted us to achieve several key findings presented in this thesis. The problems can be divided in two major groups: Those related to technological approaches, and the artistic ones. Even though the second group ended up being less demanding in the amount of time and effort, it was eventually more difficult to achieve solid conclusions in a scientific research perspective.

On the technological side we had to deal with the overwhelming and incredibly fast evolution of computer technology. The creation of the technology for the listening points, that later we called URB box, was not easy. The market didn't have any final product that satisfied our needs so we turned to microcomputer technology. We had a great starting point by studying *the locus sonus* sound map project⁵ quite extensively. It was especially useful to solve the microphone problem but the microcomputer solution that they presented seemed too expensive for us, and the software too complex. These two characteristics were a deterrent for the creation of the project, and would be a major constraint for the dissemination of the project in the soundscape and artistic community. While we dealt with this problem the Raspberry Pi project appeared and offered a very interesting and robust tool. It was not a solution per se but we decided to invest in it as a starting point to our URB box. These and other limitations are discussed in detail further ahead.

The last phase of research was the artistic application. This is always a difficult subject in scientific research. We thought about different approaches to several parts:

- How to promote artistic creation?
- To what extent can we or should we condition the act of creation?
- Follow a line of greater diversity of artists with different characteristics amongst each other or a large number of similar artists?
- How many artists is enough to be representative, to prove that a creative process is good; does this number exist or is only one enough?
- Is an audience evaluation relevant in this context?
- Should we focus more on jury of peers review or more on a self-experience conclusion?
- Should we centre our attention only on to the fluidity of working with URB or are the artistic concerns equally important in a scientific thesis?
- Up to which point can we generalize the artistic conclusions?

This area of research is always more difficult to point out the best and most solid path, much more difficult than in the technological challenges, but that is the reason that we think that multidisciplinary theses are special and important to the area, and this is probably the major opportunity to achieve results that were less likely to be reached if we do not mix, in the same group of work, the two interests, the scientific and the artistic.

Nevertheless, all the mentioned challenges were always seen from a point of view of rigor and relevance with the ultimate purpose of bringing knowledge and new ways for the communities concerned and strengthening the bonds that unite them.

⁵ <http://locusonus.org/soundmap/>

1.5 Applications of this Study

The study of sound in a soundscape context is not new. How to do it, as history has already shown us, is not only one path. However, what we propose is a different approach to soundspace capture and a new way to deal with it and its properties. This approach is a reaction to the human's (not all) most natural passive and casual listening (Chion, 1994) before their ambient sound habitat. Such a proposal presents an innovative approach based on time perspective and on reduced listening (Chion, 1983), meaning that the focus is more on the sound characteristics and how to ready them, rather than in the sound itself. Being proven that soundspace can carry very useful information about context and society characteristics and activity, and is an element that could determine the quality of life level, may even be a public health issue, there are plenty concrete situations that could benefit from the application of our research.

Our research had, as its main focus, the application of this temporal approach on soundscape applied in music creation, but the whole project has enormous potential for other areas, especially for sound ecology (as an automatic system that alerts in real time when the sound level passes a certain threshold) and historical acquis (as an automatic system to record and store important sound heritage).

Facing a huge range of applications, more than we could predict and handle, even inside our research universe (music creation application) we decided that it was fundamental to embrace an open source policy and, preferentially, easy access hardware. Towards our proof of concept, URB was developed with the purpose of being extremely easy and even inviting to adapt to each idea and necessity, whether it be within an entertainment, artistic or ecological context.

1.6 Structure of this Dissertation

In this sub-chapter we present the structure of the thesis with a brief description of each chapter, providing a guide for the reader. The thesis is divided in two major conceptual sections: contextualization and experimental process.

1. Contextualization

In this section we present the results of the literature review on the thesis topic:

Chapter 2

Framework covers the literature review and contextualization of the research in its relation with Soundscape and Music

Chapter 3

State of the Art presents a survey on the state of the art projects and technologies regarded as a reference to our study.

2. Experimental Process

In this section we present the description of the experimental process and development of the research tool, along with its applications, analysis and conclusions on the collected data and further findings:

Chapter 4

Preliminary Experiments On Soundscape Composition presents projects developed by the author that provides important insights for the this doctoral study.

Chapter 5

Research Methodology presents several approaches that contributed with methods and techniques for our study and describes the methodology followed in the course of this interdisciplinary research.

Chapter 6

URB: Prototype System for Experimental Research is dedicated to present all the details regarding the development and implementation of the proposed research tool.

Chapter 7

URB artistic applications is dedicated to present in detail all the artistic works developed through the URB system.

Chapter 8

System Evaluation and Result Analysis is dedicated to evaluate the results of the questionnaires made to the artists that used URB.

Chapter 9

Conclusions and Future Work presents the main contributions of this research project and future work to be done in this field.

Chapter 2

Framework

This chapter has the function of providing a good overall understanding of the scientific areas related to our research process. We are going to dedicate these next lines to exploration, on the general topic Sound and Technology, the Soundscapes subject in particular, while expounding the different perspectives and purposes that have been widely presented and discussed in specialised literature. Being such a vast subject, with so many different perspectives and goals, during our exposure we are going to favour and narrow the aspects that are more related to our agenda.

2.1 Related Areas and Scope of this Dissertation

This dissertation was developed under the scope of the framework of Sound And Music Computing (Serra, Ieman & Widmer, 2007) a multidisciplinary field that crosses two broad areas: Sound and Technology. Narrowing down the subject to Soundscapes and Sound and Music Technology we focus on the environmental sound dimension related to music creation.

The heart of this dissertation is constituted by two major scientific disciplines, intrinsically connected to the main framework of Computer Music:

- Sound and Music Technology
- Soundscapes

Seeing as though this research has a relatively wide range of interests, there is a 15 survey of related projects and approaches from different areas in different ways that relate to the interests of our investigation, such as:

- Musical Information Retrieval
- Algorithmic Composition
- Eco Composition
- Sound Maps

This survey confirms the timeliness, relevance and originality of the project, both scientifically and artistically.

2.2 Context Information

Sound, Audition and Society

What is Sound? According to the dictionary sound is a group of *vibrations that travel through the air or another medium and can be heard when they reach a person's or animal ear*⁶. At a first look with a more superficial approach, sound is a physical phenomenon.

⁶ “sound”. Oxford Dictionaries. Oxford University Press

Sound became an object of study in Classical Greece through studies and reflections by Pythagoras and Aristotle (Aristotle, 1987). Those first approaches were mainly from a musical practice point of view, with a profound relation between math and musical intervals. Those theories also had great philosophical reflections, contextualizing the musical creation and its function. In this period there was also a very deep incrustation of the meanings and systematization of musical practice, theorizing and organizing the musical sounds in modes (Grout & Palisca, 1988). This work was so profound, pioneering and fundamental that this theory and system marked the practice in Western music for the next millennium. During that time, the evolution on the study of sound was mainly in the musical point of view. It was only in the 19th century that a major breakthrough in the area of sound outside the musical field happened. The main people responsible were the German scientist Hermann von Helmholtz, in 1863, with *On The Sensations Of Tone As A Physiological Basis For The Theory Of Music* (Helmholtz, 2009), and the English scientist Lord Rayleigh with *The Theory of Sound* (Rayleigh, 1896).

Beside the musical and aesthetic point of view that monopolized most of the research on sound in Western history, according to Olson (1967) the physical and the physiological properties took a very important place in the sound field in the Twentieth century. It is quite clear to all, including the scientific community, that the significance that each individual gives to sounds is different. In other words, for example, a J.S. Bach *suite* does not provoke the same sensations in an Egyptian as it does in an Austrian. This is a consequence of an intrinsic part of the listening activity, a cognitive part. So along the two scientific fields mentioned before, the physical that focuses on the vibrations that travel through the air, or another medium, and the physiological that deals with the auditory system behaviour and the process from the pressure waves to the electric impulses into the brain, it is fundamental to extend to other scientific areas: anthropology, psychology and cognition (Erlmann, 2004). So not only due to the air vibrations and the auditory system, a musical piece, as is common knowledge, has different meanings and different impacts in distinct listeners. And the reason is quite complex. The cultural and musical background, the state of mind and body, a personal and emotional experience with a particular music passage, etc., are all reasons that influence and affect the act of listening. This complexity applies not only to musical contact but also to all of the listening experience. As an extreme example, an ambulance siren has completely different impacts on a resident of New York compared to an isolated Amazonian tribe inhabitant (MacAdams & Bigand, 1993).

The auditory system tends to be put at a lower level of importance than vision, mostly because the act of listening is processed effortlessly and unnoticed. At the same time, the auditory sense has a different function than vision. It is a permanently-on sense; it never shuts off. Naturally this characteristic has a survival function, providing us with the ability of permanent three-dimensional awareness, with the capacity to identify the location of a sound source, being our main door to what surrounds us outside of the view angle. To conclude, the process of perception is different to vision (Middlebrooks & Green, 1991). That permanent act of listening forced humans to develop different levels of listening or conscience about it. Most of the time a normal person relates to the sound around them in a casual listening mode (Chion, 1994), which is identifying the source and the origin

through analytical and descriptive listening, called reduced listening (Chion, 1983). This process has to be placed in passive listening, because sound is always there and the auditory system is always working. Only against a disruptive sound does our listening process turn on an active mode. As an example, if we are in a conversation in the middle of a crowd, even a very loud one, we know that the sound is there but we are in a very low awareness mode, we are not following any conversation or words beside our interlocutor. If however, a child starts to cry or someone asks for help automatically we change to an active mode. These aspects in the nature of sound have an impact on the relation that we have with our soundscapes and more importantly how we shape them and how we let them evolve.

Remaining in the same approach of the importance of sound in human evolution and behaviour, it is impossible not to approach the importance of sound as a means of communication. During most of the time of mankind's existence, we lived in the “*magical world of the ear*” (MacLuhan, 2011). According to the dictionary language *is the method of human communication, either spoken or written, consisting of the use of words in a structured and conventional way*⁷. This protocol was created and developed mainly in an aural medium. Until around the fourth millennium BC all knowledge was transmitted orally and even after that, the ability to read and right was confined to so few that, according to MacLuhan, the visual era only took the place from the aural empire with the invention of typography (2011). During the visual era in the common world, even written media, most of the world's population only had access through aural processes by indirect routes. It was only during the twentieth century that direct access to the visual language became widespread and common. The information era also started also using sound: radio broadcasting. With a purpose of education, entertainment or information, people would gather around the radio device. Radio broadcasting, was the main window, and the fastest, to the world during a big part of the first half of the twentieth century. It was the most important medium in houses in the West. To sum up, language used sound as the main means of communication between man and as transference of knowledge.

Sound is also a form of identity. Just as we have distinctive landmarks that define a specific place, sound can also have the same function. A sound *which is unique or possesses qualities which make it specially regarded or noticed by the people in that community*. (Schafer, 1993). These specific sounds are called Soundmarks, and are derived from the term landmark. This can be a natural or an artificial sound, such as the sound of a waterfall, or the way that the wind blows in that specific canyon. The fauna of certain areas, especially in the places rich in diversity of species, create very amazing and unique soundscape. The sound created by the animals can be a very strong element of representation of a geographic location. Artificial sounds are probably the more obvious soundmarks, like a factory siren et the beginning of the work shift.

From the analysis of this dimension of sound, it is very natural to start to see that these Soundmarks can also have a social and community dimension. A church bell can produce a very unique sound

⁷ “language”. Oxford Dictionaries. Oxford University Press

that can be recognized by the locals, but also has a very concrete message for all the Catholics. These sound signals are like a bond to all the religious community, as the Islam as also huge impact in the soundspace with the five daily calls to pray from the top of the minaret. In these cases it is more than a Soundmark, is also defines a community, is the acoustic space of it. This happens when a soundscape identity is coherent, *pervasive and plays an important role in the life of the community, conveying signals and cues about its rhythms and relevant events* (Cordeiro, 2013). The definition of community is *a group of people living in the same place or having a particular characteristic in common*⁸. So from that definition, the sound identity of a specific community is when shares the same sound that creates a sense of belonging, identification and meaning to a restricted and particular group. This dimension of the sound has such an enormous importance in our social lives. A community can have different sizes and characteristics.

Therefore, the boundary of the community is arbitrary and may be as small as a room of people, a home or a building, or as large as an urban community, a broadcast area, or any other system of electroacoustic communication. (Truax, 2001, p.66)

Therefore, it can be a gigantic community, like the religious one we saw before, with the calling sounds for rituals, a special calling invented for an old group of friends, a political shout, a national anthem, it can be more entertaining like a soccer team chant, but it can also be more complex such as the group of people that listen to that specific radio show every day.

After all, the soundscape is not an alien force but a reflection of ourselves. (Truax, 2001, p.117)

Aesthetics and Nature - Brief Overview

Plato stated that the form is the universal prototype of everything in nature. Every tree is struggling to achieve the pure form of “the tree”. Although all the trees are not perfect in an imperfect reality, they are still guided toward that pure form. The beauty of the tree can be assessed in regard to their participation in the realization of the form. This principle is also connected to the idea of mimesis a philosophy and practice where the artist tries to mimic nature. With this introduction of the idea of form, Plato gave the first model for a connection of aesthetics and nature. (Plato, n.d.)

Kant presents an idea somewhat similar to Plato’s, except that the place of origin of the form is different.

The aesthetic pleasure of nature comes about only if an object’s form agrees, accidentally, as it were, with a form that the imagination could have invented on its own. It is the comparison of the actual form with the counterfactual form that decides on whether we judge the object to be beautiful (Rueger, 2007).

According to Kant, when compared to the aesthetic experience of artistic beauty, the aesthetic experience of nature is only basic.

⁸ “community”. Oxford Dictionaries. Oxford University Press

Hegel's point of view about the relation of nature and aesthetics was more sceptical than that of Plato or Kant. He suggests that an aesthetic philosophy cannot be based on the beauty of nature because our assessment before it has a lack of solid criteria. Such aesthetic theory should be focused on high art with objective categories, in opposition to beauty of nature. When judging it we are before a great feeling of imprecision (Rueger, 2007).

In his commentaries, Schopenhauer comments on the aesthetic appeal of a group of natural objects. However he was cautious when contemplating the aesthetic appeal of any individual natural object. He was unable to contextualize his perspectives of the relation of aesthetics and nature with his already presented structure, with art.

Some people face nature as a phenomenal and ingenious creation of God and relate to it from that point of view, a complex construction. Others start from the assumption that aesthetics exist intrinsically to nature. Through the description of this, Malcolm Budd presents a parallel where some appreciate the object while others the creator/artist. However, he makes the distinction between that which is man-made, and that which is from nature. Non-man-made creations appreciation must be made on its own terms, and not as in an artefact. He suggested that when you experience a sound produced by natural means it is certainly not a sound intentionally determined by artistic consideration criteria (Budd, 1996). For example, a frog chant has a biological purpose like territorial domain or a mating call and not a function to provide pleasure or the questioning of dogmas. This does, however, not remove the aesthetic relevance.

An attractive conception of the aesthetic represents a response as being aesthetic insofar as the response is directed at the experienced properties of an item, the nature and arrangement of its elements or the interrelationships among its parts or aspects, and which involves a felt positive or negative reaction to the item, considered in itself, rather than as satisfying a pre-existing desire for the existence of something of that kind, so that what governs the response is whether the object is intrinsically rewarding or displeasing to experience in itself. (Budd, 1996)

Therefore, the arrangement of its elements does not predetermine the aesthetic qualities. Based on their experiences, it is possible to make an aesthetic judgement of an art piece.

According to this position, Opie and Brown say that an artist that is using eco sound structures will opt for a specific base material according to their experience of that sound, because this artistic approach is to embody the natural characteristics of the initial experience to the final art piece. However, a transfer of aesthetic experience from the natural origin is in no way guaranteed, so the art piece will be always judged as to its intrinsic value. In this way the artist is responsible for the aesthetic value. (Opie & Brown, 2010)

2.3 The Soundscape - Concept and Movement

The Soundscape concept and movement was presented to the world in the 1970s, in Murray Schafer's considerations and research. The book *The Soundscape: Our Sonic Environment the Tuning of the World* (Schafer, 1993) is the great promoter and a reference point to the Soundscape movement's dissemination. In this publication Schafer systematizes and gathers all the research already done and which was dispersed in the World Soundscape project⁹ and *The Book of Noise* written in 1968.

• Soundscape

The sonic environment. Technically, any portion of the sonic environment regarded as a field for study.

The term may refer to two different sound environments:

1. *Actual/real environments,*
2. *Abstract constructions such as musical compositions and tape montages, particularly when considered as an environment.* (Schafer, 1993, p.274)

It is reasonable to say that the soundscapes movement, because for its intrinsic material and the use that is given to it, is situated between ecological activism, documentary/reporting, the artistic documentary and acousmatic music¹⁰. According to Iges (1999), Schafer's utopia would be to implement some type of order and organization in the sound ambient with the purpose to achieve a "Sound Ecology" balance.

From the 1980s, the movement grew and became international. During this process it split into three groups:

- Sound Ecologists (Schafer followers)
- Artists that use the Sound Ambient material and freely reorganize it to create new soundspaces
 - *La ville Die Stadt*, Metropolis Paris, Pierre Henry (1984)
 - *Sound bridge Kohn-San Francisco*, Bill Fontana (1987)
 - ...
- Artists that mix, edit and process the Sound Ambient material until it is no longer identifiable. This group became more relevant and active from the year 2000 because the technological necessities, inherent to the work characteristics, only then became available on a large scale.
 - *Immersive sound*, Francisco López (2008)
 - *Electric Fauna Emiliano*, Zelada (2009)
 - ...

⁹ www.worldlisteningproject.org

¹⁰ "acousmatic music": The term acousmatic dates back to Pythagoras. The philosopher lectured the students behind a curtain because he believed that his physical presence could distract from the content of his speech. Acousmatic music is a form of electroacoustic music that is specifically composed for presentation using speakers, as opposed to a live performance. Like the Pythagoras lectures, in acousmatic music the concerts take place without seeing the source of the sound. This term was applied for the first time in musique to define the listening experience of *musique concrète*. (Schaefer, 1966)

2.4 Soundscape Ecology

During his life, Schafer noticed that the ability to listen was being lost. In his experience this was linked to a strong dominance of a visual modality in society at the expense of the aural one. Wrightson confirms that with his own experience:

As a lecturer in Music Technology, I often begin a lecture series with these exercises and I can confirm Schafer's experience: many students do not recall "consciously" having heard any sounds during the day, and many do not complete the sound list even after fifteen minutes. (2000, p.11)

This concept called *the dominance of eye culture* was developed and detailed by Berendt (1988), and faced with it he argued that listening skills should become an integral part of the Canadian curriculum.

In his studies, Schafer, with a music composition background, aims towards a balance between the natural soundscape, produced by non-human means and the non-natural soundscapes or human produced soundscapes (Schafer, 1993). This balance is subjective but, in order to be discussed, it is necessary to develop in society a high level of awareness of sound, and what surrounds it, and the inherent repercussions and characteristics. This issue had already been explored in Acoustic Ecology as a scientific subject, promoted by Schafer. To support this scientific approach, Schafer proposes a program, Ear Cleaning, for training the ear to listen more discerningly to sounds, particularly those of the environment (Schafer, 1969).

- **Acoustic Ecology**

Ecology is the study of the relationship between living organisms and their environment (...) and the study of the effects of the soundscape physical response or behavioural characteristics of creatures living within it. Its particular aim is to draw attention to imbalances which may have unhealthy or inimical effects. (Schafer, 1993, p.271)

So the perspective of this movement before Acoustic Ecology and soundscape studies is more than the momentary relation between the sound ambient and humans. As a big anthropological component, is also about the sustainability of humankind with the world, about Sound history and sources, but mainly about premeditation, consequences and art. Schafer, with a freer approach, considers all humans as musicians, which contribute to the soundscape in real time, and potential composers, that provoke permanent changes (losses and new introductions), in which he assumes that the musical work is a global soundscape.

With this we can perceive that at the heart of this movement was a large concern related to ecology and sustainability. This lack of sustainability is highly representative in one of the most extreme situations, the industrial revolution. During the 17th century, the contrast between pre-industrial and post-industrial acoustic environments it was quite dramatic. New non-natural sounds were injected into the acoustic environment. It was described and illustrated as a perfect example for the use that Schafer uses to characterize the "quality" of a soundscape:

- **Hi-Fi Soundscape**

In this type of soundscape, sounds overlap less frequently; there is more perspective between the foreground ground sounds and the background sounds. For example, on a farm the sound of a horn, a foreground sound, completely stands out from the background sounds, like the wind and the animal sounds. Another characteristic is that “acoustic horizon” may extend for many miles. According to Wrightson, the sounds emanating from a listener’s own community may be heard at a considerable distance, reinforcing a sense of space and position. (2000)

- **Lo-Fi Soundscape**

This term appears as an opposition to the hi-fi concept, which defines a system with a low ratio of signal to noise. Applied to soundscape studies, it is an environment in which signals are overcrowded, resulting in masking or lack of clarity. (Schafer, 1993) This phenomenon is very common in big cities and near industrial production centres. So in this type of a very dense (noisy) soundscape a meaningful sound can be covered and masked to a point that the aural space and the sense of space and position is quite reduced. *Under such extreme conditions, sound is either smothered (in the sense that particular sounds are not heard) or, sounds merge and sonic information mutates into anti-information: “noise”.* (Wrightson, 2000)

The Lo-Fi Soundscape is not only a matter of Ecology, is also a subject of public health. This kind of acoustic horizon is potentially harmful. It is considered that a good soundscape is an element for wellbeing and quality of life and the advances in society in an urbanism, demographic and even technological perspective rarely take this into consideration or are even aware of it. In large urban areas, the sonic experience is dominated by an overwhelming mass of automobile flux and industrial noise. (Szeremeta & Zannin, 2009). Humans are the source of the situation, with a very large lack of awareness resulting in bad urban planning and creating an unfriendly environment, but they are also the victims (De Vos & Van Beek, 2011). Studies prove that animals and humans exposed to soundscape perturbations can provoke physiological and psychological diseases (Chuengsatiansup, 1999). Lo-Fi Soundscapes, especially in industrial and dense urban areas can induce sleep disorder, constrain performance, interpersonal behaviour, cognitive development (Cohen & Weinstein, 1981) and interfere with states of mind and moods provoking annoyance, stress and, in extreme situations, be the cause of minor psychiatric disorders (Stansfeld & Clark, 2011). Unlike other kinds of pollution, the characteristics of noise contamination are not the same all over the world. They depend on such factors as the degree of development, the kind of activities involved, the population density, and even local habits and culture, among others. It is therefore important to carefully characterise the problem at each site, and to be cautious about generalising any conclusions that are drawn. So several studies have been carried out to characterise the acoustic conditions of different cities, including one or more aspect of the problem, such as noise sources, noise contamination levels, or the psychological and physiological effects of exposure to noise. (Morillas, Escobar, Sierra, Gómez & Carmona, 2002)

2.5 Soundscape Analysis/Mapping

2.5.1 Socio-cultural and Aesthetic functions

In 1977 Murray Schafer presents a Soundscape analysis typology divided in 3 parts based on their socio-cultural and aesthetic functions. This approach was later developed by Barry Truax (2001b):

- **Keynote sounds**

This term derived from the music term Key that is the same as tonality. In composition the key or tonality provides the fundamental tone from which the piece will develop and maintain, always as reference to mutations. In soundscapes, it is similar to a background sound. They are heard continuously or frequently enough to become like the key tone of a music piece, against which other sounds are perceived. Normally they are not perceived in a conscious way (Schafer, 1993). As an example, in an urban area, the traffic sound has become a keynote sound.

- **Sound Signals**

Any sound to which attention is particularly directed, such as horns, bells, sirens, and so forth. The sounds that belong to this group must have the particularity to stand out from the keynote sounds. So the characteristics change according to the time and place. For example, the timbre and volume of a current ambulance siren is different and louder than fifty years ago. And this happens because the background noise or the keynote sounds, such as traffic sound, is more dense and louder now, so the sirens have to cut through it (Schafer, 1993).

- **Soundmarks**

The soundmark derived from the term landmark and refers to a sound that belongs to a specific community, is unique, and has characteristics that are specifically identified or considered by the people in this community. As an example, a church bell can produce a very unique sound that can be recognized by the local population. This subject is presented and further explored in subchapter 2.2 - Context Information.

2.5.2 Perceptual Properties

Valle, Schirosa e Lombardo (2009), propose a supplementary classification focused on perceptual properties. This approach does not present itself as an opposition to the Schafer and Truax analysis typology, but while the first one is from a socio-cultural and aesthetic point of view, this more recent one is based on perceptual properties. According to Valle, Schirosa and Lombardo, this classification integrates elements of the Sound object theory (Schaeffer, 1977) and from Chion's research "Audiovision" (1990), classifying them into three groups:

Sound Object - *L'Objet Sonore* de Pierre Schaeffer

The Sound Object is defined by the human ear as the smallest particle of a soundscape.

- **Events**

Well-defined sound object which appears as an isolated figure. As such it is similar to Sound Signal.

- **Sound Subjects**

Represents the behaviour of a complex sound source regarding to the sequence relationships between events. That is, the description of a sound source from the point of view of a set of events and a set of sequencing rules.

- **Atmosphere**

A sound layer that cannot be analytically decomposed into single sound objects, because no sound object stands out. This concept was proposed for the first time by Bohme (2000).

2.5.3 Sound Distribution in Space

Starting in the last decade of the twentieth century, but with more incidence from the year 2000, many researchers in the soundscape area have looked into the question of the distribution of the sound ambient in space. A soundscape can be decomposed into different acoustic scenarios, which are combined through the exploratory experience of the listener. As the soundscapes are not uniform, the experience is enhanced when the listener finds aural transitions during exploration (Bohme, 2000). A listener can perceptually identify these differences thus being able to decompose the soundscape internally into sub-parts. These different sound sources from the same soundscape were referred to as “sound zones” in 2009 (Valle, Schirosa & Lombardo, 2009).

- **Sound Zones**

A sub group that together build the soundscape, they can be distinguished by the areas in the space that they occupy. The soundscape will then result from the summation of all the sound zones. For example, in a classroom (Figure 1) the soundscape consists of the voice of the teacher, Sound Zone 1, the sound from the construction work that enters the window, Sound Zone 2, the sound from the reception that enters the door, Sound Zone 3, and the sound made by a few students joking and laughing while the teacher keeps explaining. It is possible to walk around the space and cross through the several sound zones. Even if their boundaries are not well defined, each zone can be considered as completely independent from one another. This means that it is possible to describe and identify the behaviour and source of each zone. A soundscape results from the interweaving of each behaviour zone (Valle et al., 2009).

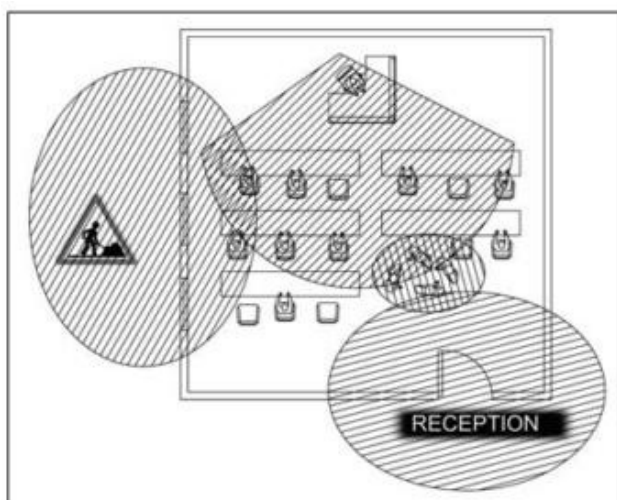


Figure 1 Sound Zones example. (Valle et al., 2009)

2.5.4 Time and Emotional Perspective

As we already referred (2.3.1 - Concept and Movement), the Acoustic Ecology and the Soundscape studies have a strong Anthropological component and at the same time a very poetic value if we see all the humans as musicians and composers co-responsible for a global soundscape. Therefore it is natural that the sounds can transform into a museological artefact with a very emotional character. Many such sounds were often regarded as unimportant when actually current; yet later, hearing them may trigger strong memories. Old or past sounds are often elevated to a different category of importance, from a historical point of view when they are associated to extinct activities or fauna, as from an personal and emotional element. Sounds experienced during childhood, for instance, often become romances for the adult. Such as the sound may have a component of pleasure, it can naturally induce the opposite in the listener. The World Sound Project observed and isolated this phenomenon that was compiled by Barry Truax in the *Handbook for Acoustic Ecology* (2001a).

- **Disappearing sounds**

Any class or type of sound which once existed, but has since been replaced, superseded, or has otherwise ceased to be heard except as a museum artefact.

Disappearing sounds are generally those associated with social activity, although some natural species and their sounds have also become extinct. When the energy forms used in society change, many direct and indirect acoustic changes result. As travel by horse gave way to mechanized transport, the sounds of shoed horse hooves, reins, sleigh bells, and wagon wheels disappeared, but so did the sound of the blacksmith and wheelwright. (Truax, 2001a)

- **Sound Romance**

Any past or disappearing sound remembered nostalgically.

Sounds experienced during childhood, for instance, often become romances for the adult. After moving away from

a given area, particularly one strongly linked with sound, such as a community by the ocean, to a place lacking those familiar sounds, these may also acquire a romantic or nostalgic quality. Other sounds go beyond having only personal romance qualities and are valued and preserved by a society as soundmarks. (Truax, 2001a)

- **Sound Phobia**

A sound that arouses fear or dislike in a person for any reason. The novelty of a new sound, particularly one that replaces an old, familiar sound, or sound signal, often causes such reactions. (Truax, 2001a)

2.5.5 Design of Auditory Displays Contexts

Depending on the purpose of the project the categories might have to be set differently. For example, Catriona Macaulay and Alison Crerar presented a research project aiming for the observation of the workspace in order to suggest new auditory interfaces (1998). They point out that one of the problems with ‘*observing the workplace soundscape during ethnographic fieldwork is finding ways to think about and represent it.*’ To fill that gap they present a way to characterise a soundscape on the basis of three dimensions:

- **Sound Type**

Speech, music, non-speech/everyday, non-speech/abstract.

- **Acoustical information Level**

Background, foreground and contextual.

- **Information Category**

Visible/hidden/imagined entities/events, passing of time, position in space, patterns in entities/events and emotions. (Macaulay & Crerar, 1998)

2.5.6 Sound Design for Cinema and Design of Auditory Displays Contexts

The categories presented here are the most representative of the soundscape communities but other approaches were introduced in a context that applies to the contemporary reality. João Cordeiro suggests that a sound design or design of auditory displays angle can be a more enlightening approach to dissect the soundscapes in specific contexts (2013). For that, he indicates the analysis code for the soundtrack of a movie stated by the composer of experimental music and theoretician on the audio-visual medium Michel Chion (1994)

- **Music**

All the music present in a movie. Element created with the goal of leading the audience emotionally (Barbosa, 2000).

- **Ambient Sound**

Sound that fills a scene and inhabits its space in the background. Due to its low profile characteristic, does not raise the question of the identification of its source but has a strong function in describing the context. For instance, birds singing, church bells ringing, cars passing by, and so forth.

- **Dialog**

Vocal speech with a semantic message. Occupies a prominent of sound area compared to the ambient sound.

- **Sound Effects**

Sounds that are added with the role of simulating the psycho-acoustic reality as we know it, and for the introduction of new concepts and sound reality (Barbosa, 2000). They usually occupy a foreground sound space.

According to Cordeiro (2013) *this systematization provides an interesting framework for the soundscape analysis, as it is more focused on the source classification of the sound events (casual listening) and their physical properties (reduced listening) rather than on the semantic meaning in a given context* (Chion, 1994).

2.5.7 Sound Maps

Sound maps are digital geographical maps that use sound to represent a specific location. Sound maps are an association of a geographical representation of landmarks and soundscapes. Now sound maps are the most effective auditory archive of an environment, touching on political, artistic, cultural, historical, and technological aspects (Järviluoma & Wagstaff, 2002). These interactive maps have placed soundscape studies and surveys in a more public and interactive place than ever before, thus promoting soundscape awareness more than ever. The Internet boosted these projects over the last ten years while capturing the public's attention and time. This format of interactive soundmap, combined with the recent capabilities of smartphones, captured the interest and creativity of acoustic societies, libraries, universities and tourist organisations alike.

The sound maps have a similar format. They are interactive maps, usually based on or inspired by the Google Maps interface¹¹. The way to navigate is through pins signs/tags that mark where sounds have been recorded at a particular geographic location. Clicking on the pins the visitor can listen to that specific soundscape. Some maps list the categories or sounds alongside the map while others use a map and search option. Increasingly, sound map projects are focusing their aims, being more and

¹¹ www.google.com/maps/

more specific. Their subject is no longer only the city or a specific geographical area, but also different subjects are appearing, such as historic, ethnographic, cultural or educational.

Sound maps take several different forms and institutional backgrounds. The most common is run by Acoustic Ecology Societies such as the New York soundmap¹² or academic institutions, such as the Sound Around You sound map¹³ supported by the Audio and Acoustic Engineering Research Centre at the University of Salford, Manchester. It is however also possible to find examples of cultural structures, like the UK Soundmap¹⁴ that is hosted by the British Library or the Seoul map¹⁵ that is hosted by Saito's Media Culture Institute and funded by Seoul's Foundation for Arts and Culture. Most sound maps have an open archive format with the intention of collecting sounds from across a city or country. More recently more and more projects with a general public participation are increasingly recurrent such as the Radio Aporee ::: Maps¹⁶, where the survey is built and supplied by spontaneous participation of the public. This is a strong proof of the effect that this project has had on the general public. (Waldock, 2011)

In subchapter 3.1 - Sound Maps we present a survey of sound map projects with the respective descriptions.

2.6 Soundscape Composition

Generalised access to new audio technology transformed the sound environment ambient into a huge and rich sound resource for composers and sound artists (Westerkamp, 1999). Due to this a countless number of compositions that use sound field recordings appeared, but that does not necessarily turn them into soundscape compositions. According to Westerkamp *the essence of soundscape composition is the artistic, sonic transmission of meanings about place, time, environment and listening perception* (1999).

¹² www.soundseeker.org (Accessed: 20 Marc 2014)

¹³ <http://www.soundaroundyou.com> (accessed, 27 February, 2014)

¹⁴ <http://sounds.bl.uk/Sound-Maps/UK-Soundmap> (Accessed: 20 Marc 2014)

¹⁵ <http://som.saii.or.kr/campaign> (Accessed: 20 Marc 2014)

¹⁶ <http://aporee.org/maps/> (accessed, 26 February, 2014)



Figure 2 The World Soundscape Project group at Simon Fraser University, 1973;
left to right: R. M. Schafer, Bruce Davis, Peter Huse, Barry Truax, Howard Broomfield

The term was applied for the first time by Barry Truax (2001b, 1996, 2000) in the context of the World Soundscape project at Simon Fraser University (Figure 2). This project had educational and archival purposes primarily but spontaneously developed an Electroacoustic music - Soundscape Composition. This practice appeared with the intent to re-present sound environment recordings. The goal was to *foster awareness of sounds that are often ignored, and hence to promote the importance of the soundscape in the life of the community* (Truax, 2002). The first case of this style was *The Vancouver Soundscape*, published in 1973 (Figure 3), consisting of a booklet and two long-play records.

The studio techniques used at that time consisted mainly of transparent editing and mixing of untransformed original recordings, selected for their aural interest and representativeness of the soundscape in question. Of equal technical importance was the attention given to the recording technique. (Truax, 2002, p.1)

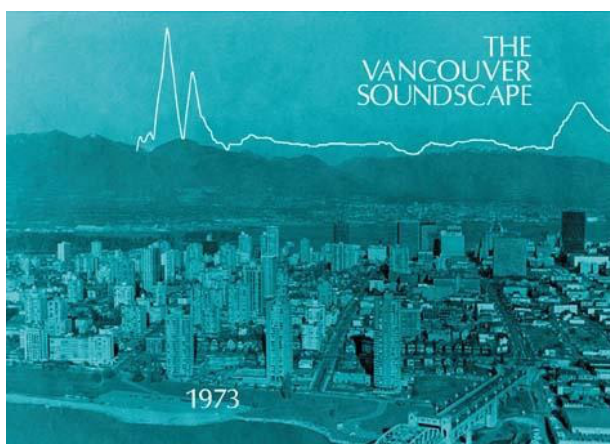


Figure 3 THE VANCOUVER SOUNDSCAPE 1973
Produced by the World Soundscape Project, Simon Fraser University

Ever since, many composers have used soundscape composition techniques, such as John Rimmer (2006), David Rothenberg, Pauline Oliveros, Hildegard Westerkamp, or Francisco López (Rothenberg & Ulvaeus, 2013).

Recorded environmental sounds are the soundscape composition “instruments” There are two “approaches” to them:

- i. Only using unprocessed sounds and the process focus on the selection, edition, mixing and organisation (with a soundscape narrative or documentation character);
- ii. Processing recorded environmental sounds. For these works to be considered sound composition, the relation to their original source, place, time, situation or context must be present in some way (Truax, 2001b). *A piece cannot be called a soundscape composition if it uses environmental sound as material for abstract sound explorations only, without any reference to the sonic environment* (Westerkamp, 1999).

Truax and later Westerkamp were very precise to define the essence of soundscape composition. It must always be rooted in themes of the sound environment and as such it is never abstract. Soundscape composition has to “inform” about place, time and situation. A piece that only uses environmental sounds as material for abstract sound explorations cannot be called a soundscape composition. The reference to the sonic environment is what distinguishes a soundscape composition from an abstract piece.

In the soundscape composition ... it is precisely the environmental context that is preserved, enhanced and exploited by the composer. The listener's past experience, associations, and patterns of soundscape perception are called upon by the composer and thereby integrated within the compositional strategy. Part of the composer's intent may also be to enhance the listener's awareness of environmental sound. (Truax, 2001b, p.207)

Soundscape composition is an artistic expression of the composer's experiences, and attitudes towards the soundscape. It is a personal sonic version.

(...) listening to such compositions, that the experience of conscious soundscape listening in daily life would add significantly to the understanding of and involvement with a soundscape composition. Composers and listeners then share the activity of listening as an important ingredient for making sense of the sound environment as well as of soundscape composition. (Westerkamp, 1999, p.5)

2.7 Eco-Composition and Eco-Structuralism

The term Eco-composition term was used for the first time in 2004 by the Art critic Robert C. Morgan to refer the Keller and Adriana Capasso's installation *Vivir sin después* (Keller & Capasso, 2006). It is a more specific posture within soundscape composition. The term is used to describe the composer role that combines aspects of ecology with compositional processes. In Eco-composition the composer works with field recordings but takes into account the history, ethnography and geography of the sound that he is manipulating (Opie & Brown, 2006). The eco-composition definition does not only involve the creation aspect, but also requires a new way of listening. The audience is invited to take the context of the sounds into consideration (Field, 2000; Keller, 1999).

Eco-structuralism is derived from the eco-composition framework, which is a new approach to music composition designed to maintain the characteristics and context of a sound whilst not necessarily using the original recording data directly. In eco- structuralism, patterns are derived from analysis of natural environmental sound sources that reveal structures within the material. This structural data are used as the dominant material for creating the musical composition (Opie & Brown, 2006).

In this kind of musical practice, although structures must be derived from natural sound sources not all the structures from a sound need to be used. A small section of the structure may be extracted and used separately. The approach to the data extracted can be very similar to the "classical" composition by using tools as elongation, compression, inversion, reversing, scaling and offsetting (Opie & Brown, 2006).

The fundamental principle of eco-structuralism is that the structure of the sound event must remain intact throughout the compositional process. The reason for maintaining structural identity is to preserve the essence and the meaning of the sound event and (more or less direct or indirectly) its context should be present within the composition.

Opie and Brown indicate a group of rules and processes to manipulate the natural sound structure without destroying it. *These rules provide guides for compositional actions. The spirit of eco-structuralism is to ensure, where possible, that aesthetic characteristics of the original sound sources are captured within the structures and will remain accessible in the final composition* (Opie & Brown, 2006). The rules are divided in two levels. A main level to present the foundations of eco-structuralism and a secondary level to guide how to put them into practice:

Primary Rules

- Structures must be derived from natural sound sources.
- Structural data must remain in series.

Secondary Rules

- The amplitude, frequency, timbre and spatial structures may all be extracted and

used as individual structures.

- Not all structures from a sound sample need be used.
- A structure may be transformed to perform a different sonic task than it initially performed.
- Small sections of the structure may be extracted and used separately, but the internal structure of that subset must remain in series.
- A structure may be transformed through elongation, compression, inversion, reversing, scaling and offsetting.
- A structure may be abstracted from, to reveal a second order underlying formative structure, which must then follow the rules of eco-structuralism.
- New tasks may be added to the set of rules as long as they obey the primary rules (Opie & Brown, 2006, p.4)

In the aesthetic dimension, eco-structuralism is supported in Aesthetic Realism philosophy. This trend is based on Eli Siegel's ideas, in which a structuralist approach is taken to the aesthetic dialectic that is based on a philosophical dialectic to explain art, nature and reality. The principle of Aesthetic Realism is that:

(...) there is no fundamental difference between the structure of reality and the structure of beauty. Moreover, the very nature of self is aesthetic. (Green, 2005, p.438)

Aesthetic Realism and structuralism share the valorisation of nature organisation and therefore acknowledges that nature contains dialectic structures or patterns or tendencies and seeing beauty in the balance of these dualities. (Opie & Brown, 2010)

2.8 Related Scope

2.8.1 Musical Information Retrieval Brief Overview

Music Information Retrieval (MIR) is an interdisciplinary science of retrieving information from music, which emerged in the late 1990s. MIR is a new way to look at problems by bringing together various fields of inquiry and paradigms, involving areas such as musicology, psychology, digital audio signal processing, pattern recognition, software system design, machine learning. The main applications are:

- Music identification
- Rights management, plagiarism detection
- Multiple version handling
- Melody extraction and retrieval
- Instrument recognition
- Performer or composer identification
- Recommender systems

- Automatic music transcription
- Style, mood, genre detection
- Music-speech segmentation
- Music generation

MIR works primarily on reducing the semantic gap between high-level musical information and low-level audio data. In the same way that humans can recognise the characteristics of sound and music, such as tempo, key, chord progressions, genre or structure, MIR algorithms enable a computer to “listen to” and “understand” audio data. As such, it gives them the ability of recognising and extracting this information enabling systems to perform extensive sorting, searching, music recommendation, metadata generation, transcription, and even aiding/generating real-time performance. MIR has applications in domains as varied as digital libraries, consumer digital devices, content delivery, musical performance or live streaming audio. (Orio, 2006; Downie, 2003)

Common methods in MIR:

1. *The algorithm attempts to find elements in the data which correspond to such entities of information already known (e.g.: melodies, harmonic progressions, rhythmic patterns).*
2. *A statistical analysis is performed on the data, by attempting (in various ways) to find common patterns in the data. Once they have been found, an attempt is made to interpret their occurrence.* (Fingerhut, 2004, p.5)

Description of audio content of digitised sound can be based on:

- General metadata (title, artist, year etc.)
- Time-domain analysis of sound,
- Frequency analysis,
- Other analyses.

The creators can provide Metadata describing for content-based searching of an audio database manually, but for musical files such metadata information is about the performer, title, year, and so forth. However, such information is sparse in a more sophisticated search, for example if someone has to query a database for all music containing a melodic phrase similar or identical to another phrase. For such a purpose, new features (descriptors) associated with audio signal have to be extracted directly from audio files. Such descriptors can be used for classification or recognition purposes.

In the Time Domain Analysis domain, the basic way to describe sound signal is to use descriptors derived from time domain of the sound. The most popular time-domain descriptors are:

- Density of zero-crossings (number of zero-crossings per frame of N samples),
- Density of peaks of time envelope,
- Differences between frames. (Wieczorkowska and Ras, 2001)

Spectral Analysis Frequency domain can be characterised using any frequency analysis method. The most popular one is based on Fourier transform, usually applied in a form of discrete Fourier transform

(DFT) or fast Fourier transform (FFT) for short time segments of the length. The following are some of the more commonly used low-level spectral audio descriptors:

- Centroid
- Kurtosis
- Flatness
- Flux
- Irregularity
- MfCC
- Roll-off
- Skewness
- Spread

(Brent, 2009; Lu, Zhang & Jiang, 2002; Tzanetakis and Cook, 2002; Malt & Jourdan, 2008)

There is also a possibility to apply descriptors based on other analyses. For example:

- Time-frequency analysis, like McAulay-Quatieri analysis or wavelet analysis
- Cepstral analysis, where spectral elements are logarithmic
- Linear predictive coding (LPC), used in speech processing (Wieczorkowska and Ras, 2001)

Although, as the name implies, MIR was developed to be applied in contexts of music, these descriptors can be applied to any sounds.

2.8.2 Algorithmic Composition Brief Overview

Cope defined algorithmic composition as:

*A sequence (set) of rules (instructions, operations) for solving (accomplishing) [particular] problem (task) [in a finite number of steps] of combining musical parts (things, elements) into a whole (composition)*¹⁷ (1993)

Alpern suggests a more direct definition:

*The area of automated composition*¹⁸ *refers to the process of using some formal process to make music with minimal human intervention* (1995, p.1)

As such, Mozart's Musical Dice Game (Figure 4) is easily inserted in this description being an extremely simple example involving the use of random numbers to piece together musical fragments (Alpern, 1995).

¹⁷ Panel Discussion in the ICMC '93, combining the definitions of the two words.

¹⁸ Algorithmic composition is sometimes referred to as "automated composition" (Maurer IV, 1999)

However, algorithmic composition has predecessors to the *Illiad Suite* (Sandred, Laurson, and Kuuskankare, 2009). For example: The above-mentioned Wolfgang Amadeus Mozart's *musikalisches Würfelspiel* (Mozart's Dice Game) and the 1821 mechanical *Componium* created by Dietrich Nicholas Winkel. The *Componium* was a mechanical musical instrument (Figure 6). The instrument plays an 80 measure piece, with eight variations for every two measures (Van Tiggelen, 1987); or some John Cage works like the *Atlas Eclipticalis* from 1961 which was composed by laying score paper on top of astronomical charts and placing notes simply where the stars occurred (Schwartz and Godfrey, 1993). It is also considered that the twelve-tone technique and serialism movements from the first half of the Twentieth century can be labelled as algorithmic or automated composition in a pure sense of the term. In these movements, composers tried to control all parameters of music (notes, rhythms, dynamics) and to abstract the compositional process. The pre-composed series and matrices of values were then the algorithms that superseded the human creative process. (Maurer IV, 1994). Olivier Messiaen's 1949 piece *Mode de Valeurs et D'Inensités* could be considered one of the most important pieces from this point of view, because all the music parameters were the result of a pre-composed series.



Figure 6 Componium

Mathematics and music have always had a close connection. For example in ancient Greece, Pythagoras stated that music and mathematics were not separate studies.

The word music had a much wider meaning to the Greeks than it has to us. In the teachings of Pythagoras and his followers, music was inseparable from numbers, which were thought to be the key to the whole spiritual and physical universe. So the system of musical sounds and rhythms, being ordered by numbers exemplified the harmony of the cosmos and corresponded to it. (Grout & Palisca, 1996, p.843)

However the ancient Greek approach was mostly in theory. The “formalisms” were never totally applied to the musical performance because Greek music was almost entirely improvised. (Grout & Palisca, 1996)

In the 19th century, Ada Lovelace, inventor of the precursor of computers, the “calculating engine”, had already predicted that in the future technology would bring scientists and composers together, making possible the use of algorithmic programming methods to create “complex” pieces of music:

Supposing, for instance, that the fundamental relations of pitched sound in the signs of harmony and of musical composition were susceptible of such expression and adaptations, the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent. (Bowles, 1970, p.4)

In addition to the above mentioned *Illiad Suite: Quartet No. 4* one of the most important pioneers of the use the computer in algorithmic composition was the composer Iannis Xenakis. In the beginning of the 60's, he created a program that would produce data for his stochastic¹⁹ compositions. Processes that he had described in great detail in his book *Formalized Music* (Xenakis, 1992) (Figure 7). The program generated scores from a list of notes densities and probabilistic weights provided by the programmer, leaving specific decisions to a random number generator. (Alpern, 1995)

Through computation it was possible to introduce the algorithmic composition statistical theory and Markov, introducing a great amount of conceptual complexity. More recently a different use of unpredictability was implemented. This approach uses chaos theories to feed the algorithms. This means the use of non linear equations that have been deduced from nature and other chaotic structures (Leach and Fitch, 1995).

In recent years [the '70s and '80s], the behaviour of systems of nonlinear dynamical equations when iterated has generated interest into their uses as note generation algorithms. The systems are described as systems of mathematical equations, and, as noted by Bidlack and Leach, display behaviours found in a large number of systems in nature, such as the weather, the mixing of fluids, the phenomenon of turbulence, population cycles, the beating of the human heart, and the lengths of time between water droplets dripping from a leaky faucet. (Alpern, 1995, p.7)

¹⁹ “stochastic” having a random probability distribution or pattern that may be analysed statistically but may not be predicted precisely. Oxford Dictionaries. Oxford University Press.

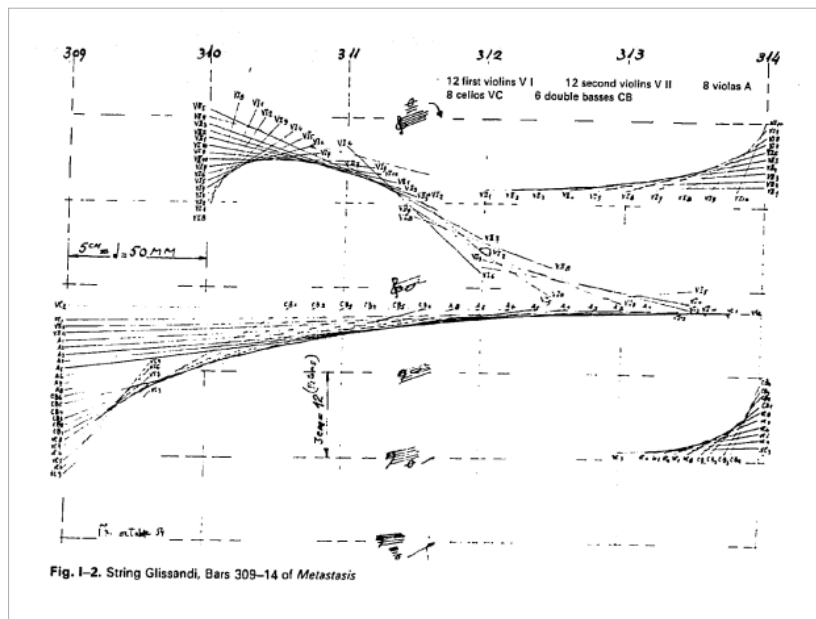


Figure 7 Extract from a stochastic piece. (Xenakis, 1992)

The most recent approach to algorithmic composition is the use of Artificial Intelligence systems. These systems are like rule-based systems (e.g. Illiac Suite) but they have the capacity to “learn” and thus to define their own grammar. For example, the David’s Cope EMI (Experimental Music Intelligence). This system is based on a large database of style descriptions of different compositional strategies adding the capacity to develop its own grammar and database of rules. The computer itself deduces based on several scores from a specific composer’s work that are input to it. (Maurer IV, 1999)

More recently, the sub-area of AI techniques consists of a *genetic programming* approach (Alpern, 1995). Rather than basing its grammar on scores input to the computer, such as in EMI, genetic programming generates its own musical materials as well as forming its own grammar. The most important, and interesting, point is that the composer must also program a “critic” function, therefore, which then listens to the numerous automatically produced outputs at various stages of the processing to decide which are “fit” or suitable for final output. So genetic programming:

is a method which actually uses a process of artificially-created natural selection to evolve simple computer programs. In order to perform this process, one uses a small set of functions and terminals, or constants, to describe the domain one wishes an evolved program to operate in. For example, if the human programmer wishes to evolve a program which can generate or modify music, one would give it functions which manipulate music, doing things such as transposition, note generations, stretching or shrinking of time values, etc. Once the functions have been decided on, the genetic programming system will create a population of programs which have been randomly generated from the provided function set. Then, a fitness measure is determined for each program. This is a number describing how well the program performs in the given problem domain. Since the initial programs are randomly generated, their performance will be very poor— however, a few programs are likely to do slightly better than the rest. These will be selected in pairs, proportionate to their fitness measure, and then a

new population of programs will be created from these individuals, and the whole process will be repeated, until a solution is reached (in the form of a program which satisfies the critic), or a set of number of iterations has passed. Operations which may be performed in generating this new population include reproduction (passing an individual program on into the next generation unchanged), crossover (swapping pieces of code between two 'parent' programs in order to create two unique 'children'), mutation, permutation, and others. (Alpern, 1995, p.11)

Algorithmic processes in music have not been used only to generate scores but also to generate the sound itself in a sound synthesis approach. Sound synthesis algorithms *have been used in a variety of ways, from the calculation of complex waveforms, to the evolution of timbre development over time* (Burns, 1997).

The most recent branch of the algorithmic composition is artificial intelligence (AI) systems that work in real time, responding to what the computer is “listening to”. In this area, composers are working on computational models of perception and cognition of music using AI approaches. These new techniques improve algorithmic composition since the “critic” functions that we have seen in examples of genetic programming could gain much improvement from their insights into how humans listen to music: the computer could, then, better judge itself as to the quality of its output. (Maurer IV, 1999).

Chapter 3

State of the Art

In this chapter we present a survey of projects that show some scientific or artistic relation with the study of capturing, analysing and (re)composition soundscapes, as well as being representative of the state-of-the-art being produced in this domain. The criteria to include them in this list were: the originality and the overall quality of the projects, both in scientific and artistic terms, and the proximity with some dimension of our project (in particular the approach and the relation with the capture and listing of the sound environment, and the artistic approach to that data). A large number of projects that we also consider to be relevant for our research were left out of this list since they touch only very specific aspects of our project, or they are a recreation to an idea that is already presented. For example, social networks based on uploaded sounds (e.g. Freesound.org (Akkermans et al., 2011), that although may have an enormous collection of soundscapes, both in the essence of the collection as well as mapping, show a rather different immediate aim of use when compared to ours. The same can be said about the dozens of quality sound maps, which are a repetition of the same principle or process already presented.

This survey is divided into 3 categories:

- Sound Maps
- Metadata Database From Soundscapes Based Projects
- (Re)Composing (with) soundscapes
- Research Projects

The separation is mainly for ease of reference and consultation. Although they are categorised by the part of most interest to our research, most of them are multidisciplinary and easily embrace more categories of study.

3.1 Sound Maps

In the subchapter 2.5.7 - Sound Maps we present a description of the sound maps framework and context; this section is a survey of sound maps projects with the respective description.

3.1.1 Montréal Sound Map²⁰

The Montréal Sound Map is a web-based soundscape project that allows users to upload field recordings to a Google Map of Montréal. We decide to use this project as an example of the classic sound maps that are growing in number in recent years. The Montréal is one of the first sound maps, and represents the approach and the paradigm for similar projects that appear later.

²⁰ <http://www.montrealsoundmap.com/> (accessed, 21 February, 2014)

The interface is presented on the website platform, and offers a way to explore and listen to the city with a purposeful and special attention that is rarely given to the sounds of the environment (Figure 8). The soundscape is constantly changing, and the aim of this project is to act as a sonic time capsule with the goal of preserving sounds before they disappear and to stimulate people to continue this attentive listening and experience the complexity and lure of the soundscape first-hand. The authors believe that the Sound Map promotes a more optimistic approach to acoustic ecology, encouraging listeners to lend a musical ear to the soundscape.

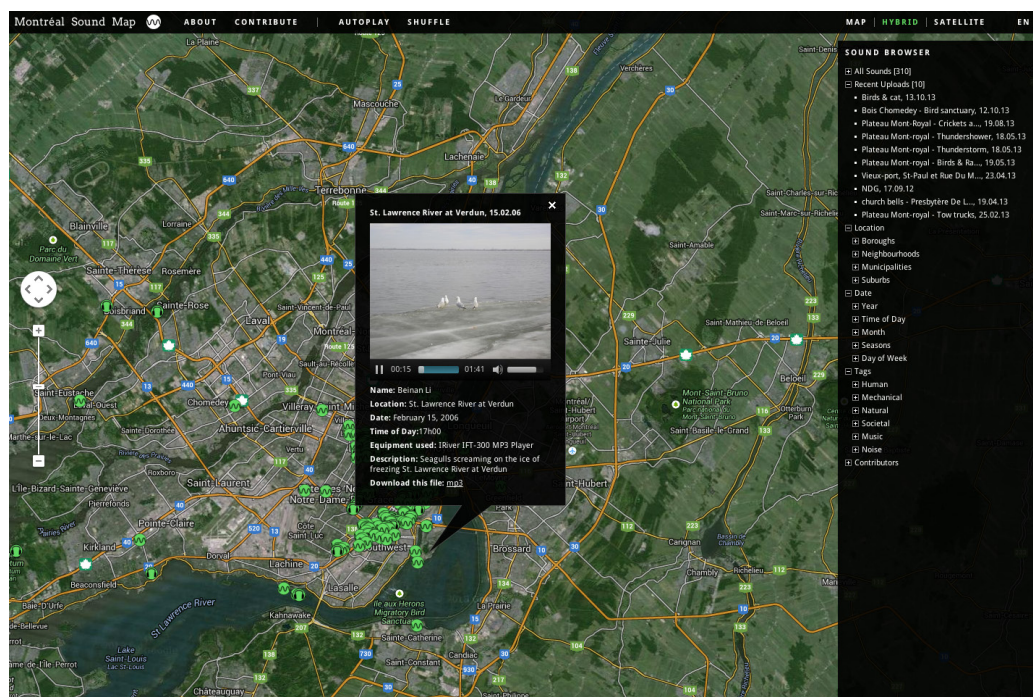


Figure 8 Montréal Sound Map website interface

To date, this Sound map has 310 sounds since the year 2002 and allows the user to access the field recording directly using the map or searching by tags: Location (Boroughs, Neighbourhoods, Municipalities and Suburbs), Date and Type (Human, Mechanical, Natural, Societal, Music and Noise).

3.1.2 Stanley Park Soundmap²¹

The Stanley Park Soundmap, created in 2009 by Richard Minardi, is a web-based document of the sonic attributes of one of North America's largest urban parks located in Vancouver, British Columbia,

²¹ <https://www.sfu.ca/geog/geog351spring09/group07/html/index.html> (accessed, 26 February, 2014)

Canada (Figure 9). This sound map has two particularities: it is focused only in a park/natural area and all the recordings were made on the same day, a sunny day on Thursday, March 12, 2009. The location data and sound recordings were then linked to a map created in a Geographic Information Systems (GIS) based desktop application.

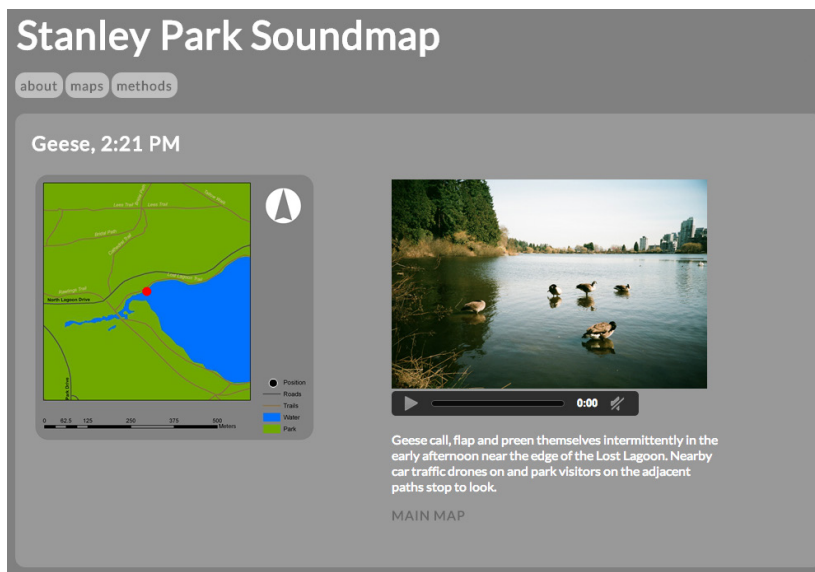


Figure 9 Stanley Park Soundmap website interface

To our knowledge this is the only sound map in which all the sounds were recorded on the same day. That gives us a sound representation of a large area in the same time lapse. Although it is a different approach to the temporal element in the sound capture of a sound map, it is still missing a reflection/systematization for the approach and more collection days for the comparison to be possible.

3.1.3 Sound Around You²²

Sound Around You is sound map of the world developed by the Audio and Acoustic Engineering Research Centre at the University of Salford, Manchester. This project serves a research project about how sounds in the everyday environment influence people. (Mydlarz, Drumm and Cox, 2011) They ask people across the world to use their iPhone (or any other audio recorder) to record clips of around 30 seconds in length from different sound environments and to upload them to the virtual map, along with their opinions of (Figure 10).

²² <http://www.soundaroundyou.com> (accessed, 27 February, 2014)

The authors took advantage of the advances in mobile computing in two aspects:

- It enables environmental soundscape data from a large participant base to be automatically collated and analysed.
- It enables participants to include subjective responses to the soundscapes they inhabit, providing a more nuanced understanding of the context and reasons for human responses to environmental sounds.

They developed a small application for mobile devices. As well as the capturing of audio, all device configurations allow for the logging of subjective response data from the participant. This feature was developed because the researchers believe that the data gathered from the participant while immersed in the soundscape will provide a more accurate impression of the impact of the individual's soundscape as they are responding in situ and not relying on memories of a sound space, which may be inaccurately recalled. The recent advances in Global Positioning System (GPS) integration into mobile devices also allow for the “stamping” of location and time information on each captured soundscape.

For each soundscape captured using the projects mobile software or the web interface the participant has to fill in a survey about subjective characteristics of the sound (Table 1).

Subjective measure	Description (scale from 1 – 9)
Overall location quality	Rating of the location in general (bad <- -> good)
Soundscape quality	Rating of the soundscape in general (bad <- -> good)
Soundscape pleasantness	Rating of how pleasant (unpleasant <- -> pleasant)
How exciting	Rating of how exciting (boring <- -> exciting)
How eventful	Rating of how eventful (uneventful <- -> eventful)
How tranquil	Rating of how tranquil (chaotic <- -> tranquil)
Positive sound	Text entry of one of the sounds that contributes positively to the soundscape
Positive sound prominence	Rating of how much the above sound stands out within the soundscape (small <- -> large)the soundscape
Negative sound	Text entry of one of the sounds that contributes negatively to the soundscape
Negative sound prominence	Rating of how much the above sound stands out within the soundscape (small <- -> large)the soundscape

Table 1 Descriptions of subjective semantic differential scales. Sound Around You project (Mydlarz, Drumm and Cox, 2011)

The semantic differential scales used in the project were chosen from previous research (Kang and Zhang, 2010; Dokmeci and Kang, 2010; Dubois, Guastavino and Raimbault, 2006; Kim, Song, Park and Lee, 2010), who determined the most influential measures of soundscape quality in the use of four semantic differentials. From this survey, the researcher can evaluate the relationship of people and activities with the soundscape and create metadata for the sounds in the archive.

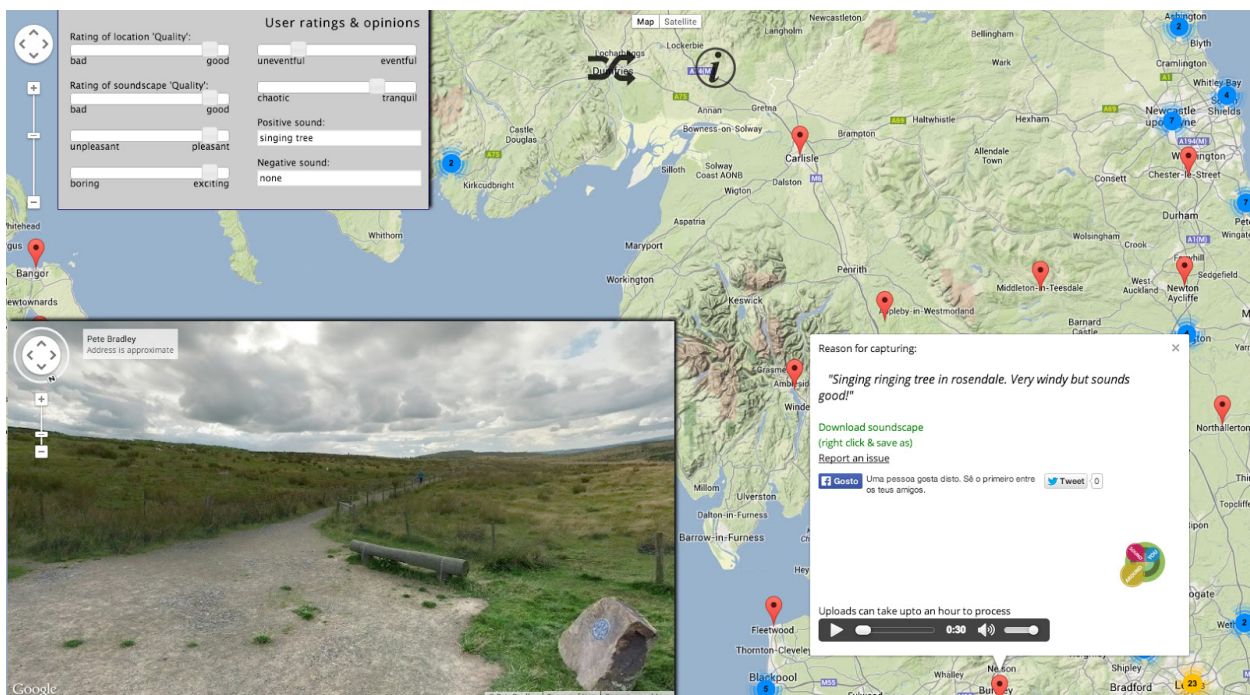


Figure 10 Sound Around You Soundmap website interface

3.1.4 Sound Wonders - Sound Tourism for Travellers²³

The Sound Wonders is a sound map completely focused at tourist motivations made especially for travellers, and that characteristic makes this project unique and original. Sonic Wonders is authored by Trevor Cox, Professor of Acoustic Engineering at the University of Salford. This project, made up not by sound but by references for possible places with interesting sounds and other acoustic phenomena. The users can interact with the archive using the classic sound map or by tag/classification. The sounds in the map are divided by a colour code, classified by the editor, by raking: “Worth a journey”, “Worth a detour”, “Interesting” or “Unrated”. When you click on the pin you have a small picture and a description of the sound phenomenon (Figure 11). Although it doesn’t have the usual sound file, you

²³ <http://www.sonicwonders.org/> (Accesses: 21 Marc 2014)

have a direct link to a more detailed description and a very clarifying video of the sound (can be from a documentary or even an amateur video) and a logistic text for the journey and suggested locations with similar phenomena. This website project already resulted in two books, *Sonic Wonderland: A Scientific Odyssey of Sound* (Cox, 2014a) and *The Sound Book: The Science of the Sonic Wonders of the World* (Cox, 2014b).



Figure 11 Sonic Wonders sound map with raking classification

3.1.5 Open Sound New Orleans²⁴

The Open Sound New Orleans is a different project from the traditional sound maps because the community is the main focus. More than a soundscape survey of the city, it is a cultural, musical and identity project. Participants are impelled to participate with sounds and voices in their life and adding them to the soundmap. The authors intent is to make more accessible the authentic, unedited sounds and voices of New Orleans. The map interface is organised into three types of sounds: Ambient Sounds, Music Sounds and Voice Sounds (Figure 12). So together with the soundscapes recordings you have, musical jams, interviews and speeches of local concern. Other of the interesting characteristics of this project is that they, in order to facilitate a diversity of direct dispatches from around our city, lend recording equipment and offer training in its use. We decided to introduce this project in our survey because although is not the project with the highest scientific concerns, in our opinion is a

²⁴ <http://www.opensoundneworleans.com> (accessed, 21 Marc, 2014)

wonderful example of how soundscapes research is serving the general public by bringing people to their sound heritage and identity while developing awareness of the sound that surrounds them.

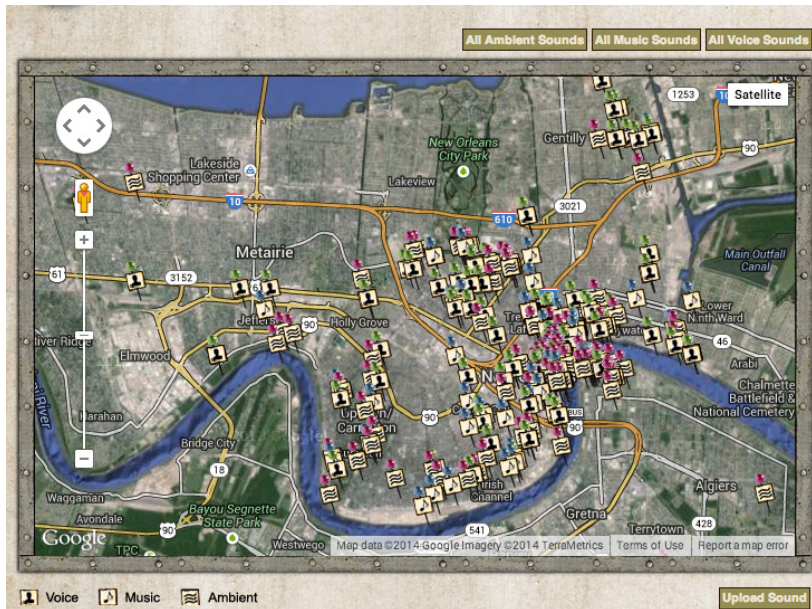


Figure 12 Open Sound New Orleans sound map interface with ambient, music and voice sounds discrimination

3.1.6 The Roaring Twenties²⁵

The Roaring Twenties website is dedicated to aural history, attempting to recreate, for its listeners, not just the sound of the past but also its sonic culture, developed by Emily Thompson and Scott Mahoy. It offers a sonic time machine, an interactive multimedia environment whereby site visitors cannot just hear, but listen to, the noises of New York City in the late 1920s. It also offers an informational environment of media and data. Letters, forms, photographs, sound motion pictures, all constitute a network of content and context.

The sonic content at the heart of this journey consists of fifty-four unique excerpts of sound newsreel footage, Fox Movietone newsreels from 1926 through 1930. The films come from the Moving Image Research Collections of the Libraries of the University of South Carolina. Foghorns, shouting peddlers, rumbling elevated trains, pounding riveters, and laughing children were all captured by the microphones and cameras of the Movietone men as they crossed the city searching for news.

²⁵ <http://vectorsdev.usc.edu/NYCSound/777b.html> (accessed, 28 February, 2014)

To construct a context for listening to these historic sounds, the site presents a rich collection of data and documents from the Municipal Archives of the City of New York.

There are three complementary ways to access the content:

- **Sound**

The Sound interface organises the content by type of noise using categories from the era. It is also possible to select and access documentation of complaints and newsreel footage of specific kinds of noises, from newsboys and barking dogs to steam shovels and radio loudspeakers (Figure 13).

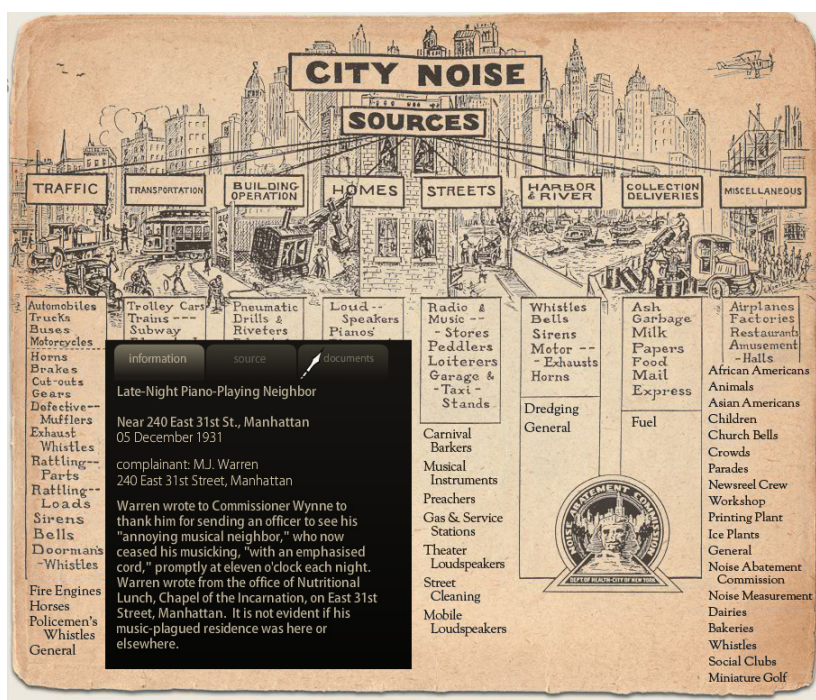


Figure 13 Sound Interface. The Roaring Twenties project

- **Space**

The Space interface organises all the complaints and newsreels onto a street map of the city from 1933. All five boroughs can be navigated by the familiar Google map techniques (with the image of an old map of New York City), enabling the visitor to explore specific neighbourhoods and discover the noises that characterised each particular locale (Figure 14).

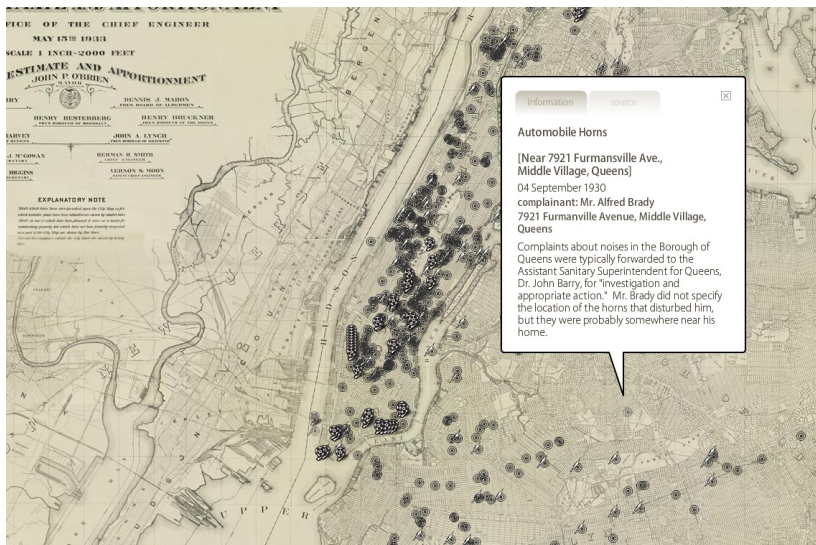


Figure 14 Space Interface. The Roaring Twenties project

• Time

A Timeline organises the material chronologically (Figure 15).

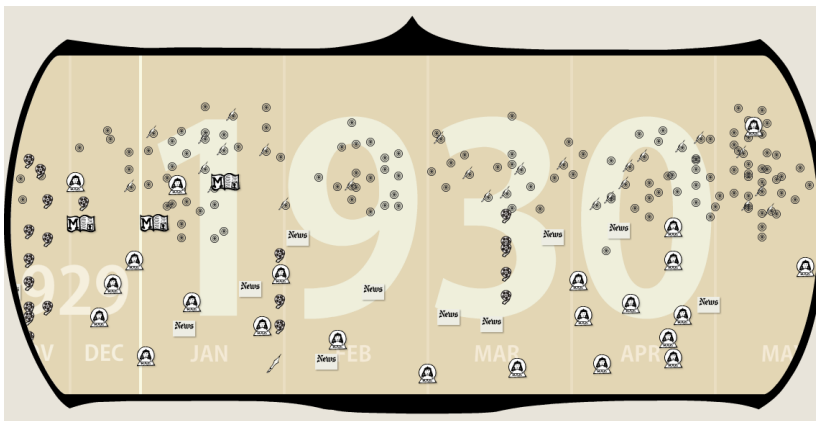


Figure 15 Time Interface. The Roaring Twenties project

Within each interface, specific items are called up by clicking upon icons representing: noise complaints; noise complaints with accompanying documentation and newsreels.

This project, in our opinion, is particularly interesting because of the historical approach. But our interest is also in the alternative approaches to interact with the sound library. Not only with the classical geographical map but also from a type of noise and in a time line. In this case we have double

3.1.7 Radio Aporee :: Maps²⁶

Figure 16 Project radio aporee ::: maps interface

This project has 22417 sounds from 19248 places being one of the largest repositories of sounds in this field. This project has a unique approach to the listener offering several ways to listen. Besides

²⁶ <http://aporee.org/maps/> (accessed, 26 February, 2014)

the regular map interface, it can also function as a radio playing the last sounds uploaded, a random version, playing all the sounds of a specific geographic region or a geo mixer (that allows real time mixing of several sounds in the map). It also allows for contributors to create personal or project sound maps. In these cases the listener only can access to sounds in that project/theme.

Being an open collaborative project the public benefits from being able to achieve this global archive, however it is impossible to control both the level of quality and intention. In our opinion, this project's fragility is the lack of assertiveness and focus because has too much content of a diverse nature, e.g. mixing sound ambient with a sound of a man climbing the stairs in his own house. From the soundscape research point of view is slightly chaotic, but we consider that it is an unavoidable worldwide public sound project, demonstrating the extent that a collaborative and open public project can acquire.

3.1.8 British Library Sounds - Sound Maps

The British Library Sounds²⁷, included in the British National Library²⁸ is an archive of 50,000 recordings and their associated documentation from the Library's collections of sound recordings from all over the world that covers a wide range of subjects. In this archive there is a group of interactive sound maps with different types or recordings: regional accents and dialects, wildlife and environmental sounds, and selected world and traditional music. For each theme they have a specific sound map. This is a very interesting way to observe different application of sound maps increasingly away from the exclusivity of soundscape studies. For example, this library has a sound map exclusively for accents and dialects²⁹ or traditional music in England³⁰, or even more unusual situations like an oral history collection with recordings from the Jewish survivors of the Holocaust³¹, alongside the classic soundscape map. This is an interesting demonstration of appropriation of this way to interact with sound archives by major institutions outside the restricted circle of the ecological sound archives.

3.1.9 Stereopublic: Crowdsourcing The Quiet³²

Stereopublic: Crowdsourcing The Quiet is a project created by the sound artist Jason Sweeney for mapping the silent areas. It is a participatory project to help create a unique record of different places and make

²⁷ <http://sounds.bl.uk/> (accessed, 21 Marc, 2014)

²⁸ www.bl.uk/

²⁹ <http://sounds.bl.uk/Sound-Maps/Accents-and-Dialects> (accessed, 21 March, 2014)

³⁰ <http://sounds.bl.uk/Sound-Maps/Traditional-Music-In-England> (accessed, 21 March, 2014)

³¹ <http://sounds.bl.uk/Sound-Maps/Jewish-Holocaust-Survivors> (accessed, 21 March, 2014)

³² www.stereopublic.net/ (accessed: 26 March, 2014)

people more aware about their sound environment. In urban areas, silent places where one can enjoy some quietude are getting more and more scarce. The sound intensity and characteristics are increasingly identified as harmful to human health and disturbing to a balanced life. With cities still getting more crowded and thus louder every year, this is a highly relevant topic. This point is quite interesting because what seems to be a purely ecological soundscape project is presented by the author as an art project, demonstrating the close relationship between soundscape awareness and artistic expression.

Besides the classic website sound map (Figure 17), the project has an app for smart phones with which it is possible to consult the silent places and have access to audio walks. The project presents walking tours that have been created for activated cities by a city sound surveyor. They present a route that allows the user to take up to an hour to discover quiet spaces in the city.

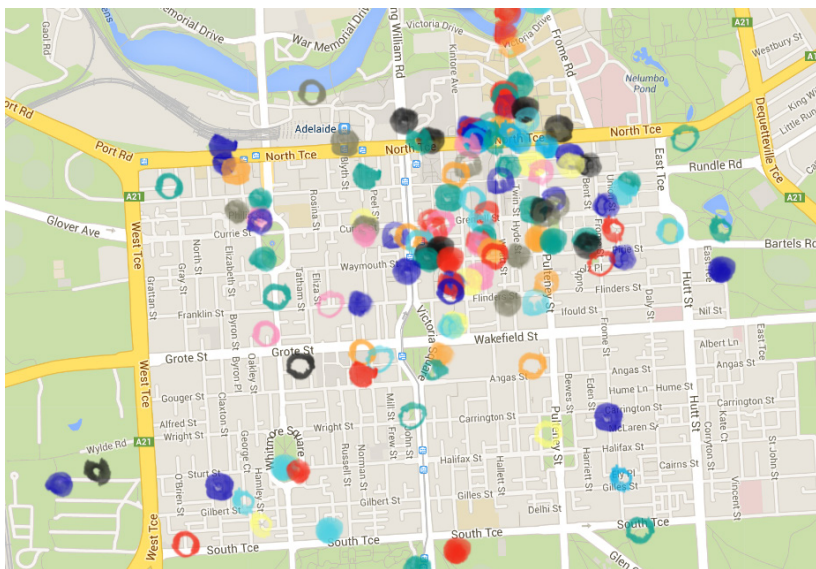


Figure 17 Stereopublic: Crowdsourcing The Quiet sound map.

The project also has a music section. Users can ask for a musical composition for a specific quiet place. So on the map you have two symbols, a not filled circle marking a quiet space and filled circles that are marking a quiet space but with a musical composition associated to that place (Figure 18).

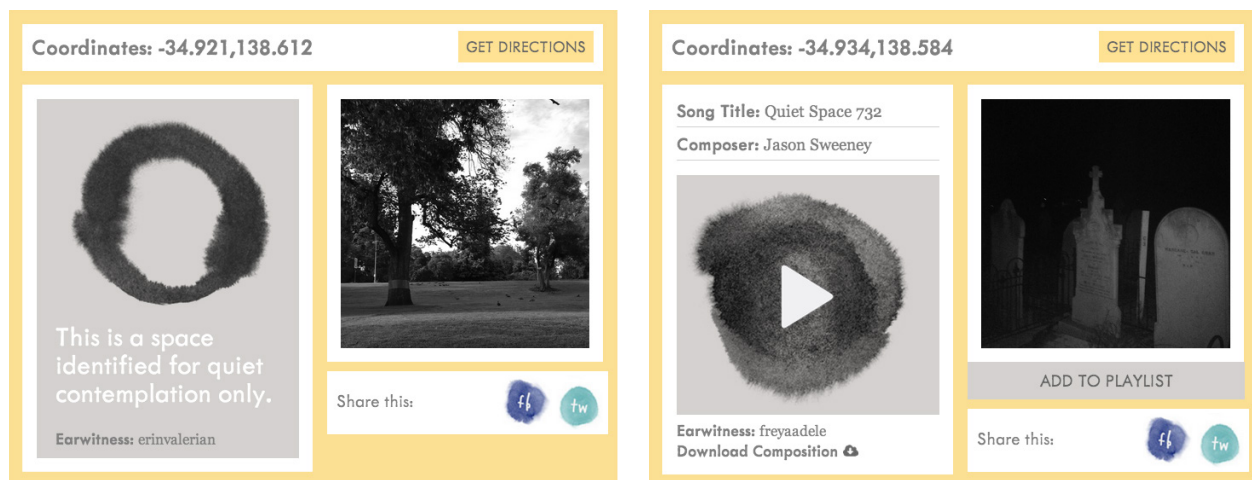


Figure 18 Stereopublic project: On the left a not filled circle marking a quiet spaces. On the right a filled circle marking a quiet space with a musical piece associated to that place.

3.1.10 Porto Sonoro³³

Porto Sonoro is a project started in 2012, which encompasses works around the sound heritage of the city. This project seeks to identify and catalogue all kind of records that clearly describe the Porto historical centre, from its soundscape, sound marks, localised musical elements, phonetics and phonology. It works as a documentation and research centre (Magalhães and Costa, 2013).

The documentation is divided into specific sound categories:

- **Imaginary sound paths** - It is proposed to various sound artists a real or imaginary sonic journey where the original sound sources are combined and processed to obtain a personal interpretation of the sounds of the Porto Historic Centre;
- **Voices (voice)** - Pub conversations, everyday expressions, slang;
- **Stories (identity)** - Short statements related to the city;
- **Streets (feature)** - Trading sessions, traffic, street musicians;
- **Sound Mark (specificity)** - Fountains, bells, traffic lights, “microscopic” detail recordings: granite, doors, river, etc.;
- **Celebrations and events (celebration)** - Markets and flea markets, festivities, masses, soccer games, sporting events;
- **Acoustic spaces (resonance)** - Tunnels, churches, museums, subway (Magalhães and Costa, 2013).

³³ www.portosonoro.pt (accessed, 25 February, 2014)

The separation into different categories, complemented by images that fit the sounds cartographically, will also draw conclusions in the long term, where it is possible to make an assessment of the evolution of the acoustic quality of urban space. The authors believe that this data can then be evaluated by architects, sociologists and environmentalists to thereby develop urban projects with appropriate acoustic solutions.

There is also a Sound Map section where a large number of sound collections is provided, properly identified and mapped. It is a classic sound map with the particularity of using a colour code to identify which category a sound belongs to (Figure 19).

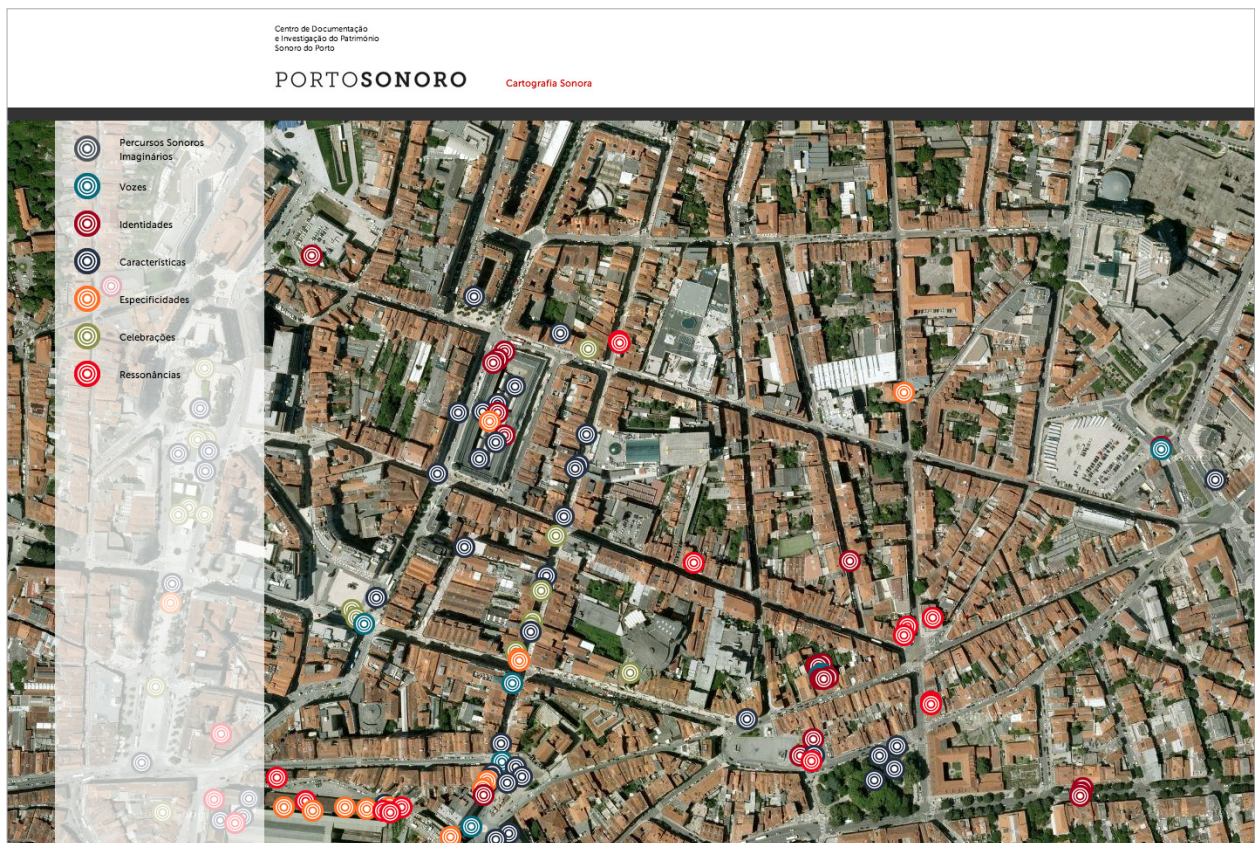


Figure 19 Porto Sonoro sound map with a colour code identification.

Porto Sonoro is particularly relevant to this study for several reasons. This project is not only a collection and archive concerning the place with sound; it is more than that. Porto Sonoro has a cultural social and identity purpose. It wants to define and work with sound heritage. According to the authors, sound heritage means all kinds of sound events that feature and clearly describe the historic centre of Porto. So the place where the recording is made it is only one part of the process. The main element is the content. The sound of traffic is similar everywhere, but slang, festivities or acoustic spaces are part of a cultural identity. Another important element of this project is the artistic process after the

recordings. They promote an interaction between this sound library and the sound art community. Several artists were invited to create pieces with the sounds of Porto and to present them live. The approach is similar in all the pieces. The sounds are reorganised in a time line and mixed together. Then are more or less processed digitally with classic effects like delay, reverb, spectral freezes, etc. but always recognisable. Later in some parts musicians improvise with electronic or real instruments with the new/artificial soundscape. Although there is no systematic process in the artistic approach, these specific events are key in order to create a relationship with this language to form a critical mass for future reflections and possible conclusions.

3.1.11 Locustream Sound Map³⁴ & Locustreambox

The Locus Sonus sound map is a project from the research group Locus Sonus. This research group, launched in 2004, is organised as a postgraduate lab by the Art Schools of Aix en Provence (ESAA) and Bourges (ENSA) in France. It is concerned with the innovative and transdisciplinary nature of audio art forms, in the framework of networked sonic spaces. The main goals that define this research is audio in its relation to space and networked audio systems. The main headings are: Sound and Distance, Field Spatialization, Networked Sonic Spaces, Audio Fluxes, Sonification, and Internet Auditoriums. (Sinclair, 2007)

Locustream Sound Map is an audio-listening map of streams emitted by open mics around the globe. It is part of the various interfaces that have been developed from the device Locustream open mics. As the Locus Sonus is inherently nomadic in nature, shared between 2 institutions separated by several hundred kilometres, it was decided that some live audio streams be set up, basically open microphones which upload a given soundscape or sound environment continuously to a server and from there be available from anywhere via the internet. The intention was to provide a permanent resource to tap into as raw material for artistic experimentation. (Sinclair, 2007)

After several projects using these open mics the researchers seemed necessary to provide the “streamers” (musicians and artists connected to Locustream projects) with the possibility to access the streams themselves, to hear their own sound and sound provided by other people (Sinclair, 2007). The map website interface shows the location of all the streams and indicates those which are currently active, inactive and those that are inactive but have a record session of the place. For each stream spot the location and its description, the operator and sometimes a photo of the place are also provided. By clicking on a chosen active location it is possible to listen directly (in real time) to the sound in that part of the globe (Figure 20).

³⁴ <http://locusonus.org/soundmap/035/> (accessed, 5 March, 2014)



Figure 20 Locusonus Sound Map interface with live stream active

To support the project, the research group developed an autonomous LocustreamBox - a small computer dedicated to task streaming audio and configured to connect automatically to their server and related systems such as online interfaces or setups for installations. The LocustreamBox is formed by Linux Xubuntu, nano-pcs, Pd, Max/MSP, Holospat, Junxtion and LocusMic (Joy & Sinclair, 2008). The LocusMic³⁵ is a very small electret microphone with all the components into the sleeve of the jack. The electret is powered by the streambox (circa 5V) (Figure 21).



Figure 21 LocustreamBox + LocusMic

³⁵ <http://locusonus.org/w/?page=Locustream+LocusMic> (accessed, 5 March, 2014)

This project is very important for our research because, as we demonstrated previously, usually the sound maps are based on a Google-style map that is used to situate the geographic origin of the recordings. However, according to Truax, most of the times lacking any coherent temporal perspective, and usually lacking any interpretative analysis or with subjective/emotional interpretations. He also refers to the Locustream Sound Map as an interesting variant of this approach because of its constantly streaming audio.

This project has also demonstrated an enormous relevance and practicality in the artistic and academic fields. In partnership with artists and research centres interested in networked music and sonic performance, it has developed into one of the important parts of the recently created NMSAT (Networked Music & Soundart Timeline) to support important collaborations in this area such as Euphonic (with SARC Belfast, CRiSAP LCC University of the Arts London, CultureLab University of Newcastle, LORNA Reykjavik, KIBLA Maribor, Le Hangar Barcelona, STEIM Amsterdam), Audio Ambiances (LAMES CNRS Université de Provence, CRESSON CNRS École d'Architecture de Grenoble, ENST/Telecom Paristech/Eurocom Sophia-Antipolis/EHESS), TransatLab puf—Franco-American academic partnership (School of the Art Institute of Chicago SAIC) (Joy & Sinclair, 2009). Also of particular relevance is the open source and public participation character, such as the DIY hardware development. This allows for the hardware not to become an impediment to the proliferation of the project.

Note: During the writing of this thesis, the Locus Sonus project launched Locustream Pi Box. It has the same characteristics of the Locustreambox but is based on the Raspberry Pi microcomputer³⁶.

3.2 Metadata Database From Soundscapes Based Projects

In this section we present a survey of projects that use metadata from soundscapes as their main element.

3.2.1 WideNoise³⁷

WideNoise is a project that demonstrates the power of the new mobile devices to create and constantly develop a sound map for a specific intent. In this case sound pollution. It is a project developed by the

³⁶ <http://locusonus.org/w/?page=Locustream+Raspberry+Pi> (accessed, 13 January, 2015)

³⁷ <http://www.widetag.com/widenoise/> (accessed, 5 March, 2014)

University of Wuerzburg and the University of Kassel in the context of the EU project EveryAware. This application is also part of the Ubicon platform (Atzmueller et al., 2012).

This project consists of an application for mobile devices operating systems that transforms them into calibrated sound meters. Thus measure the sound and create an intensity map that can be accessed by users, in order to learn about their surrounding soundscape.

For each sound spot submitted the user has access to the dB value, the date, a group of subjective perception parameters and tags of the sound origin filled in by the users. It is also possible to search by degree of intensity and or by tag/type of sound origin (Figure 22).

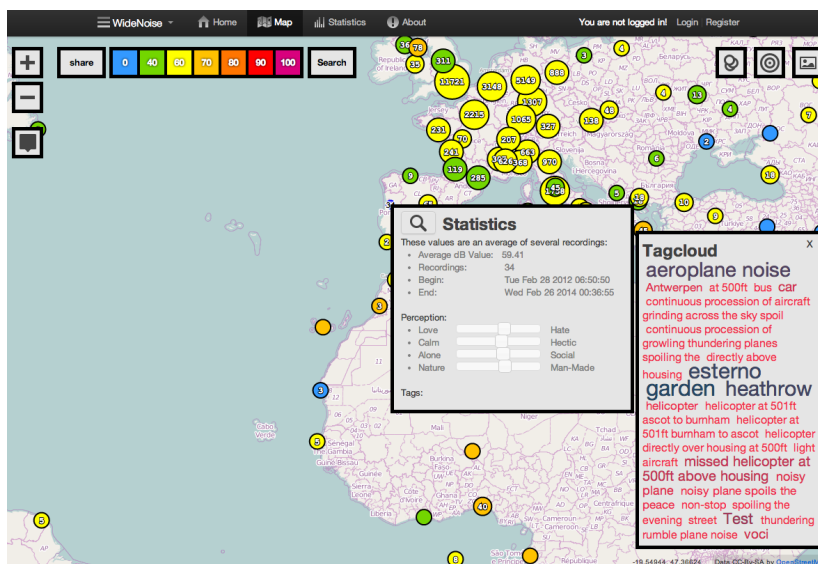


Figure 22 Widenoise Sound Map This

3.2.2 NoiseSpy

NoiseSpy is a project that uses a mobile phone for participatory urban noise monitoring and mapping in real-time. Through an app, which transforms a conventional mobile device into low-cost data logger for monitoring environmental noise. The system allows users to know in real-time, which are the most quiet/noisy areas. This is done through the visualisation of collective data, sound intensity and GPS (Figure 23) (Kanjo, 2009).

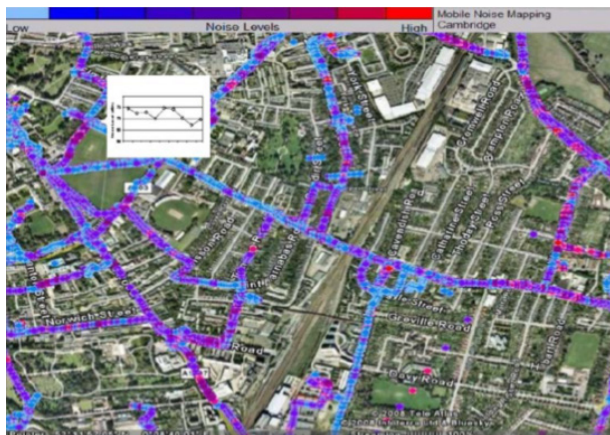


Figure 23 NoiseSPY Noise Mapping. Colored traces represent the loudness in dBA (Kanjo, 2009).

3.2.3 SoundFishing

This project is a prototypal application that senses the sonic environment. According to some rules, pre-established by the user, the software extracts particular samples of it (Midolo, 2008). Although it is only a prototype, this project reveals the interest for the soundscape awareness and the power of the new technologies to create bonds between citizens and sound ambient through the intelligent computer systems.

3.2.4 Hurly-Burly

The Hurly-Burly³⁸ project (Cordeiro, 2013) is to our knowledge, one of the most relevant projects of capturing and building a metadata database from sound environments. The starting point of the project is to use the user as the centre of the sound environments and to use the metadata in a social network context, sharing soundscapes characteristics between friends.

The main goal of the project consists in evaluating the role of sound in the social media domain, mainly regarding soundscapes or the acoustic environment of places. The author believes that sound holds important information about places/peoples activities and by sharing this information within our social network new and welcomed interactions take place (Figure 24).

³⁸ Hurly-Burly is part of the PhD research, Sound-Based Social Networks, developed by João Cordeiro at the Research Center for Science and Technology of the Arts (CITAR) - Portuguese Catholic University in Porto - Portugal. It is supervised by Professor Álvaro Barbosa and Co-Supervised by Professor Luís Gustavo Martins.

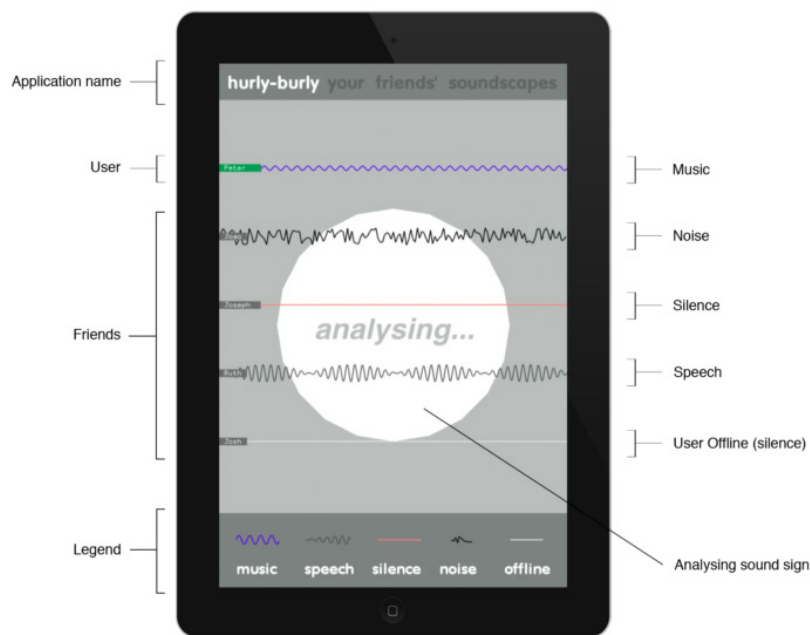


Figure 24 Hurly-Burly's GUI explained. (Cordeiro, 2013).

The Hurly-Burly is made up of four main blocks: soundscape-sensing, information visualisation, sonification and database. The software application for mobile devices (iOS) analyses the sound with a $\pm 2,79$ seconds mono audio samples (44.1kHz, 16bit), recorded every 3 minutes (or whenever the user double taps the device's screen) in the user's surroundings by means of the on-board microphone. The data collected and distributed by the system is:

- The classification of the captured sound (music, speech, environmental sounds),
- Its loudness,
- Quantity of movement
- Timestamp

The soundscape-sensing module was built using visual programming language Pure Data³⁹ (Pd) and embedded in the main C++ code using a software wrapper called LibPD⁴⁰.

This module is responsible for the classification of incoming sound, consists in the implementation of a set of patches and objects TimberID, created by William Brent in the Pd and the machine-learning algorithm chosen is the k-nearest neighbour (k-NN).

³⁹ Originally developed by Miller Puckette, <http://puredata.info>

⁴⁰ Official webpage: <http://libpd.cc>.

The gathered data feeds a database on a web server, which constitutes the nucleus of the network. All registered peers can write and read from this database. With the system running on all clients' devices, users can see a real-time visualisation of their “friends” individual soundscapes, without demanding any active input interaction from those.

The author realised that sound classification is less accurate when the users are on the move, due to the fact that they usually carry their devices inside pockets or bags. So the last input to the project was, through the device's accelerometer, to implement a movement tracking system and share that information within the “friends”.

- *All the data collected by the client application is stored on a server using MySQL open source relational database management system.*
- *The application analyses sound and movement once a minute and uploads this information into the database via an HTML form sent to a PHP script hosted on the server.*
- *Every thirty seconds the client application sends an HTML form to a PHP script querying the database about friend's updates, which fuels the visualisation on the mobile device. On the other end, a temporal display of the collected data is made available through a web-browser using a Column Chart, with continuous time on the x-axis and sound intensity on the y-axis (0 to 120 db LeqA (2,79s)).*
- *There are five possible categories (columns/ colours) in which sound analyses can be displayed: music (green), speech (red), silence (purple) and rejected (blue) when the algorithm can't recognize the sound source. A Line Chart regarding information relative to the movement of the device is displayed on top of this chart (Figure 25). (Cordeiro and Barbosa, 2013)*

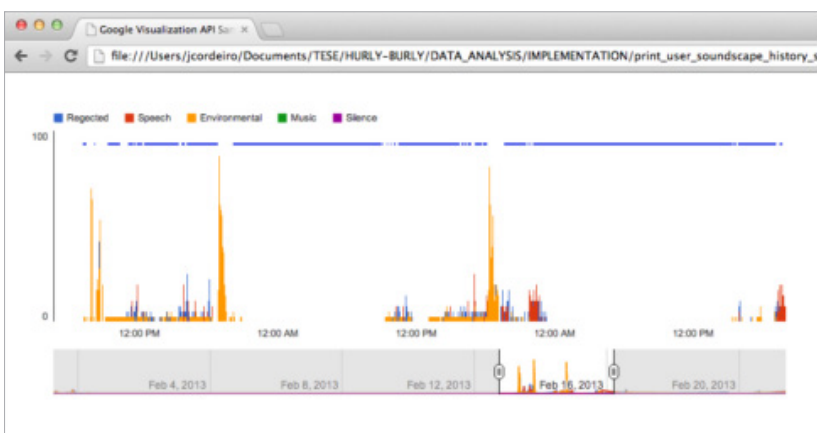


Figure 25 Temporal monitoring of sound and movement. (Cordeiro and Barbosa, 2013)

This project is particularly relevant because is a very significant state of the art of a project that works with soundscape but only using the information about it and not the sound itself. With this degree of ability of analysis of the sound, it is possible to work with almost infinite quantities of sound and automatically store a spread only the relevant information.

3.2.5 A Pilot Study of Urban Noise Monitoring Architecture using Wireless Sensor Networks

This is a study proposing a system for monitoring urban noise automatically and permanently. In this project they propose wireless sensors to analyse the sound pressure and to send data via the Internet to a database. (Gubbi, Marusic, Rao, Law, & Palaniswami, 2013)

They present a solution that combines two types of sensors. Fixed and mobile infrastructure:

- *Fixed infrastructure in this context is a realization of WSNs (Wireless Sensor Networks) in urban monitoring. The proposed architecture is two tiered including high communication, low processing power backbone node and a low communication, high processing power-sensing node.*
- *The mobile infrastructure can include sensors mounted on vehicles, mobile phones and other handheld devices. They are useful in people centric approaches where the citizens will contribute to city council's policy making. They enrich data collected by fixed infrastructure by filling gaps in spatial data and help citizens in filing noise complaints where fixed infrastructure facilities are not available. (Gubbi et al., 2013)*

In this study a hardware platform for fixed infrastructures that processes the noise signal in analogue domain and converts it into sound levels, ensuring privacy protection, is presented. Adding the wide availability of mobile sensors (e.g. smart phones) that presents other opportunities for collecting vital environmental information (Figure 26). The authors propose a spare mobile participatory sensing layer for noise data collection. To this effect, a mobile phone application is being developed for Android and iOS platforms. The visualisation and interpretation of the data is achieved using Google maps.

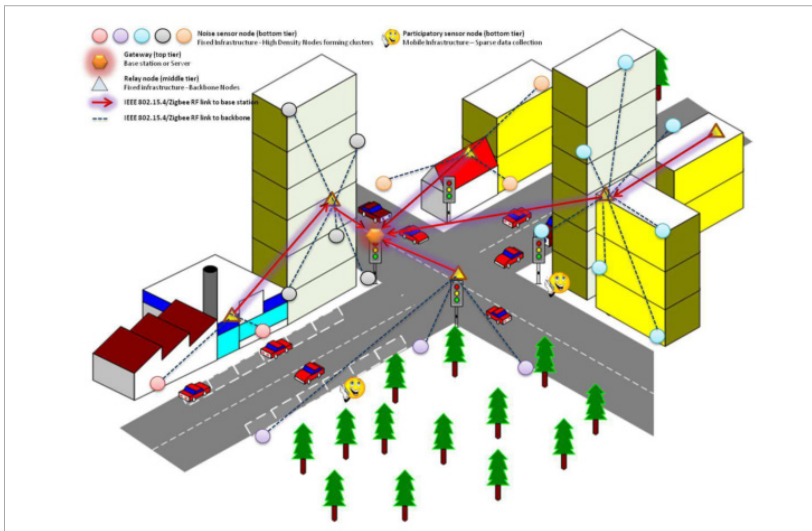


Figure 26 Architecture of the proposed scheme based (Gubbi et al., 2013)

3.2.6 SENSEable Pisa

SENSEable Pisa project⁴¹ aims for the development of tools and practices for the analysis and study of urban environments. Its intention is to gather and process large volumes of data about the environment and human activities, exploring information to describe not only the urban environment, but also some aspects of social behavior.

A network prototype with the purpose of measuring noise levels was created. The network is composed of sensors capable of communicating with each other, located in several points all over the city. Each device is a small sized micro-controller equipped with a low-cost acoustic sensor, a zigbee interface and a solar panel.

The devices are based on Arduino and low-cost condenser microphones. The data generated is collected in a round-robin database (RRD) designed to store and analyse temporal data series (Figure 27). The devices detect noise levels once every second. The logarithmic average of the measurements over a 10-minute interval is then recorded in a database.

Although the project is at a very early stage of implementation, conceptually and technically it is a great example of a project for monitoring and storing urban soundscape data.

⁴¹ www.senseable-pisa.it/en/info/ (Accessed, 9 September, 2014).



Figure 27 Noise level data from SENSEable Pisa project.

3.2.7 Ear-it

Ear-it⁴² is a trial project for city monitoring through sound. Launched as part of the autonomous community SmartSantander⁴³. The system is capable of using city noises to detect things such as traffic congestion, parking availability and the location of emergency vehicles based on their sirens. It could then automatically trigger smart signs to display up-to-date information, for example. The project is particularly focused on a junction near the city hospital that is a hotspot for motor accidents. Rather than force ambulance drivers to risk passing through a red light and into lateral traffic, the sensors are able to detect when and where an emergency vehicle is coming through and automatically change the lights in their favour. The system is being developed to also be used for picking up sonic events, such as gunshots or explosions, and detect their location.

⁴² www.smartsantander.eu/ (Accessed, 10 December, 2014).

⁴³ www.smartsantander.eu/ (Accessed, 10 December, 2014).

Although the project is at an experimental stage and published results or processes haven't yet been published, this project demonstrates the growing awareness of data taken from the urban soundscape and its practical application.

Note: This project was developed and published during the writing of this thesis.

3.3 (Re)Composing (With) Soundscapes

In this section we present a survey of artistic projects with their respective descriptions, which use the soundscape as the main material for their creation and that relate to our research. In the subchapters 2.6 - Soundscape Composition and 2.7 - Eco-Composition and Eco-Structuralism, we present a description of the soundscape artistic framework and context.

3.3.1 X Marks The Spot⁴⁴

X Marks The Spot is a project by Matilde Meireles that started in 2012. It is a very original and *playful way of mapping Belfast through sound*. This project is a very original idea to use the soundscape in an artistic way in which to engage people with the space around them. The centre of the project is telecommunication boxes and the audible drone that they emit. The first boxes tagged were those that the author passes by daily and therefore have a closer relationship, but now everyone can participate in the process. For that reason Meireles asks people to send her an email with the location of the box and a very short text indicating:

- *If you spotted the box by chance or do you pass it regularly*
- *Describing the surroundings of area around the box*
- *What was the time and date when you spotted the box?*

This has the purpose of spreading the project throughout Belfast creating a stronger connection between the people within the city. The most interesting part is that the drone of each telecommunication box is going to be the material for a composition connected to that specific spot. This composition can be heard through a QR code printed in a poster placed onto the box. The poster also includes 9 frequencies that compose the drone (Figure 28).

⁴⁴ <http://xmsbelfast.com/> (accessed, 24 February, 2014).



Figure 28 X Marks the Spot- One telecommunication box with the QRcode for the composition.

The artist made a very explanatory list of tasks, with the process to tag the telecommunication boxes and map Belfast:

- *Spot a telecommunication box emitting an audible drone (continuous hum). Any possible help will be great!*
- *Record its sound always using the same contact microphone.*
- *Analyse this recording to note the main frequencies and amplitudes that compose the sound.*
- *Assemble an A2 poster including just 9 of these frequencies and a QR code that will give access to the web-archive.*
- *Print the poster on a black and white laser printer.*
- *Place the poster onto the telecommunication box.*
- *Photograph the result.*
- *Construct an idealized version of each sound using results from step 3 and analysis/resynthesis. (Supercollider analysis/resynthesis by Miguel Negrão)*
- *Use an induction coil pick-up to search for the changes in the magnetic field generated by the box. Then choose and record a 2 minutes sample.*
- *Create a 2.52 minutes composition that explores the sonic identity of the box using the two previous recordings and analyses/resynthesis.*
- *Upload to the web-archive the photograph, the short sound composition and a small text indicating how the box was found and/or the person relation with the place.*⁴⁵

⁴⁵ <http://xmsbelfast.com/process> (accessed, 24 February, 2014).

Although the life of the posters will be short, because they are placed in the street, it is possible to check all the tagged boxes through the web archive.

This project is particularly important to our research because uses the soundscapes in composition. The pieces are intrinsically connected to specific places, using information about the sound and not only the soundscape itself.

3.3.2 Sundial⁴⁶

Sundial is a Justin Bennett on-going project to document the 24-hour rhythm of cities. Is mainly a documentation project but with artistic concerns in the presentation. The reason that we include this project is because the approach to the time dimension in the soundscape documentation. The Author makes “time-lapse” sound recordings from a single point in a city during 24 hours. These are then edited to form a continuous piece of about 8 minutes, allowing the listener to hear the changes at an accelerated pace. During the piece it is not possible to understand the “time jumps”, however the soundscape changing through the course of the day is quite understandable.



Figure 29 Sundial Vienna production photo, 2003-2013

⁴⁶ http://jubilee-art.org/?rd_project=191&lang=en (accessed, 20 February, 2014).

The recordings are made with a “soundfield” microphone allowing a 3d reproduction of the original soundscape, which adds to the immersive quality of the piece. Up to now the cities include Paris, Brussels, Amsterdam, Istanbul, Guangzhou, Barcelona, Vienna (Figure 29).

This project is a work in progress and therefore does not feature in any scientific publication, yet; we are including it here considering the relevance of the supporting platform (Jubilee) and the author’s portfolio.

3.3.3 Sonic City

Sonic City is a project that developed a wearable system that analyses several contextual cues. This data is used to produce a sonic artistic output laying in the area of soundscape composition and electronic music (Mazé & Jacobs, 2003). This project is interesting for our study because it uses, among others, sonic contextual cues (which most of the times can be from a soundscape context), to gather data to feed a system that automatically creates an artistic sonic output. (Gaye, Mazé, & Holmquist, 2003)

3.3.4 Cities and Memory⁴⁷

Cities and Memory is a sound project that attempts to record both the present reality of a place, but also its imagined, alternative counterpart – remixing the world, one sound at a time.

Cities and Memory is a classic sound map with an artistic upgrade. This project is quite relevant to our research because it has the unique feature of mapping faithful field recording soundscapes that are accompanied by artistic reworking, a processing or an interpretation which imagines that place and time as somewhere else, somewhere new.

The interface is through a classic sound map, but for each location, the map presents the field recording, city version, and a rework version, memory version (Figure 30). There are no rules for the reinterpretations, but the general approach is through the processing the soundscapes (reverb, delay, etc.), relocate the sound events in time (cutting, looping, etc.) and in some particular cases adding musical/instrumental elements.

As such, it allows the listener to explore locations through their actual sounds, accompanied by deviations and explorations to interpretations of what those places could be, or to flip between the two different sound worlds at leisure.

⁴⁷ www.citiesandmemory.com (accessed, 20 August, 2014)

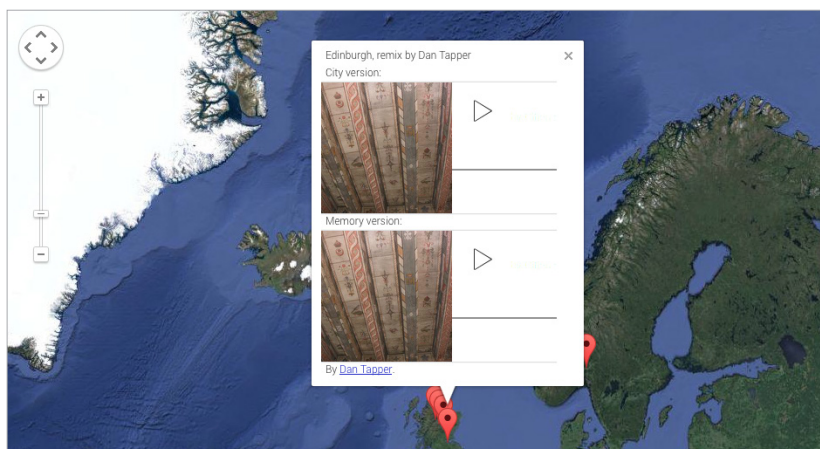


Figure 30 Cities and Memory interface with field recording (city version) and rework (Memory version)

3.4 Research Projects

The research projects in the soundscapes area are, fortunately, numerous. Faced with the impossibility of including them all, we decided to reference those who are active and who have a close relationship to the creative (musical) process.

3.4.1 Soundscape of European Cities and Landscapes

The Soundscape of European Cities and Landscapes is a project/action part of COST⁴⁸. COST is an intergovernmental framework for European Cooperation in Science and Technology, allowing for the coordination of nationally funded research on a European level. The main purpose of this project is to provide the underpinning science for soundscape research and make the field go significantly beyond the current state-of-the-art, through coordinated international and interdisciplinary efforts. The Action will promote soundscape into current legislations, policies and practice, aiming at improving/preserving our sonic environment. (Schulte-Fortkamp & Kang, 2010)

The action starts from the concept that reducing the sound level, which is the focus of European Union environmental noise policy, does not necessarily lead to improved quality of life. They point to the paradigm that research soundscapes beyond not only physical measurements but also the cooperation of human/social sciences (e.g. psychology, sociology, architecture, anthropology,

⁴⁸ <http://www.cost.eu/>

medicine). Environmental sounds are considered a resource rather than waste. The Action does this by workshops, seminars, conferences, short-term scientific missions, and summer schools. (Axelsson, 2012).

Although this action has a focus mainly on the ecological and urban planning area, naturally the music, connected to soundscape practices, is emerging as a partner in the study of urban soundscapes. As a strong example is the EchoPolis International Conference⁴⁹ (integrated in Soundscape of European Cities and Landscapes), that the relationship with music is an essential part of it as demonstrated in the title of the conference: Sounds, noise and music for re-thinking sustainable city and eoneighborhood.

This demonstrates how relevant this subject is. Both ecological sense as in the cultural and anthropological sense, where the music, or music processes, appear as a fundamental tool of relationship and identity appropriation.

3.4.2 Recomposing the City: Sonic Art and Urban Architectures⁵⁰

Recomposing The City was initiated in 2013 by Dr Gascia Ouzounian (Music & Sonic Arts) and Dr Sarah Lappin (Architecture), and is a collaborative research group based at the Institute for Collaborative Research in the Humanities at Queen's University Belfast. The purpose is to gather researchers and artists from a variety of disciplines, music and sonic arts, architecture and planning, geography, anthropology, film studies, and creative writing. What follows is the question that drives the project:

How can sound artists and architects working in collaboration generate new ways of analysing, understanding, and transforming urban spaces?

One very important quality is the partnership beyond research and artistic centres like the not-for-profit organizations Forum for Alternative Belfast, CIC (FAB) and PLACE, the Built Environment Centre of Northern Ireland. This feature is presented as an asset in the relation to the public interest and enabling a wider application of issues and projects.

Since the start Recomposing The City has led and promoted a series of seminars, workshops, concerts and an international symposium with the central question:

How can connections between sonic arts and architecture generate new ways of understanding, analysing and transforming urban environments?

⁴⁹ <http://www.event2013.sd-med.org/en/>

⁵⁰ <http://recomposingthecity.org/> (accessed, 20 February, 2014)

This project is quite recent, however we decided to include it in our projects survey because we considerer that the main subject that drives it is rather similar to ours. The main value of this project was that in a few months it created a favourable context for discussion, research and collaboration between academic researchers and artists within this field This resulted not only in conferences and workshops but also concerts, valuable reflections and field projects. This work is being documented in surveys of sound art works in Belfast and how that interacts with the soundscape like The Walk Home:

A sound installation in the MAC's corridors wherein the sounds of visitors' footsteps merged with "the sound of footsteps made by thousands of shipyard workers returning home," described by the artists as "an iconic aspect of Belfast's aural identity"; Call for Work, in which factory horns evoking Belfast's industrial past—created in collaboration with community participants who recalled these ubiquitous soundmarks (Ouzounian, 2013, p.48)

or the Belfast Sound Map :

An interactive, online platform that allows users to upload field recordings as well as commentary about the Belfast soundscape (...) Listening to the recordings featured on Belfast Sound Map, it is striking to note the extent to which a city's unique character and identity can be described in sound, whether through local accents and speech patterns, the sounds of everyday business and leisure activities, traffic and transportation, or natural and environmental soundscapes. (...) inadvertently the project has entered the realms of acoustic ecology as well as social commentary. (Ouzounian, 2013, p.48)

Chapter 4

Preliminary Experiments on Soundscape Composition

In this chapter we present preliminary experiments related to soundscape composition. Several projects are described, representing correlated experiments by the author, his team and occasional participants in the course of the PhD program. We have decided to include this small survey of works as they provided us with fundamental cues, experience and knowledge in these particular artistic and scientific areas related to the main topic. The most significant aspect of these projects is that they proved to be essential for the reasoning of the central question as to the formulation of the proposed system. They all share the underlying goal of this research: to promote soundscapes among artists and people in general. By describing the processes and results of public presentations, we identified approaches reinterpreting raw data in music composition. Furthermore, some considerations are inferred about the artistic relevance of using this approach.

These works were created for different audiences and formats, but always with the main purpose of using the soundscape as the main source material. It was intended to work with the soundscape not only as an inspiration, or recreating a new soundscape with the sound itself, but also to use this material as the fundamental material for the structure, melody and harmony. Apart from the intention to use the soundscape in music composition, the main goal was to achieve an artistic result that should be motivating and challenging for the author, the musicians and the audience.

The four projects presented in detail are:

- **Antonomásia_O Porto – Padrões Sociais Invictos**

A music piece for live electro-acoustic performance (with soundscapes from Porto), electric guitar and multi percussion. Work curated by Sonoscopia Cultural Association⁵¹ for the Manobras no Porto Festival 2011⁵². September 2011.

- **Snapshot - Som urbano sob fundo branco I**

A sound installation only using the Porto soundscape. Work curated by Sonoscopia Cultural Association for the Manobras no Porto Festival 2012. September - October 2012.

- **Concerto X (section)**

Music piece for tape, chamber orchestra and improvisation ensemble. Commissioned by Guimarães 2012, European Capital of Culture⁵³. October 2012.

- **L'arbre des songes**

Music piece for tape (quadriphonic sound system). Work curated by the composer and researcher Rui Dias⁵⁴ for the 4th International Festival of Contemporary Music of Livorno⁵⁵, 2012.

⁵¹ <http://sonoscopia.pt/>

⁵² <http://manobrasnoporto.com/>

⁵³ <http://www.guimaraes2012.pt/>

⁵⁴ <http://www.ruidias.pt/>

⁵⁵ <https://sites.google.com/site/suoniinauditi/home>

- **PORTOphone - iOS app.**

Music application curated by Digitópia Casa da Música.

4.1 Antonomásia_o Porto - Padrões Sociais Invictos

Antonomásia_O Porto – Padrões Sociais Invictos (Antonomasia Porto - Undefeated Social Standards) is a music piece for live electro-acoustic performance (with soundscapes from Porto, sound synthesis and live sound processing), electric guitar and percussion (vibraphone, waterphone and multi percussion), curated by Sonoscopia Cultural Association for the Manobras no Porto Festival 2011.

The Manobras no Porto Festival, is a challenge to Porto to find itself and try it on its historical centre. It is a two-year event - 2011 and 2012 - to convoke movement, life and action, to appeal to people and ideas, to create a here and now involving the faces and bodies of the city, to produce and to show knowledge and feeling, to build future in the city. For Manobras no Porto, Sonoscopia (cultural association) developed the project Sons do Porto (Sounds of Porto), a project that focused on the historic centre, addressing the areas of documentation, research and artistic reinterpretation. The Sons do Porto consists of several categories/events: Levantamento do Património Sonoro do Porto (Survey of Porto's Sound Heritage), Ciclo Novas Composições (New Compositions Cycle), Oficinas de Ritmos Populares e Construção de novos Instrumentos (Popular Rhythms and Construction of New Instruments Workshops) and Ciclo Ruas do Povo (Peoples' Streets Series). This composition was presented in the New Compositions Cycle and tried to embrace the spirit of the festival (Figure 31).



Figure 31 Antonomásia_O Porto – Padrões Sociais Invictos live performance at Manobras Festival.

This piece fits in a register of improvised music. The score delivered to the musician was not a classical score but a group of instructions with the structure and with some performative indications.

The electro-acoustic section has the main function to lead the piece and the transitions between sections. The instruments, following the instructions in the score (instrument, ambient, melodies or rhythmic cells), should interact with the recreated soundscape.

The sound recordings were divided into 5 groups (Bells, Coffee Shops and Markets, Trams, Birds and Rhythms). These sounds were played and mixed in real time and whatever group of sound was playing was what defined the section of the piece and how the instrument players would interact. The order of the sections is always decided by the electro-acoustic section in real time.

The piece works in a dialog between the Porto soundscape and the instruments. In some moments the concrete sounds are more dominant, in other moments the abstraction of the musical elements takes control, but always in very progressive and organic changes and evolutions.

Music file <http://jasg.net/URB/Antonomasia.mp3> and Appendix A

4.2 Snapshot - Som Urbano sob Fundo Branco

Snapshot - Som Urbano sob Fundo Branco (Urban Sound on White Background) is a sound installation curated by Sonoscopia Associação Cultural for Manobras no Porto Festival displayed at the Casa do Infante Museum, in the historic centre of Porto - UNESCO World Heritage centre, in 2012.

This installation has the objective to transform the urban sound material into an art element. This is accomplished by isolating it from its source and blending and masking purposely with the local and live soundscape. The installation consists of 19 small speakers, one turntable, a vinyl record and a computer running a Max patch (Figure 32).



Figure 32 Snapshot - Som Urbano sob Fundo Branco sound installation

This intervention focuses on two important parts: The first is the isolation of small Porto sound moments into a format normally dedicated to the artistic or musical sound dimension. Which fragments are audible or not is a public decision during the action to play or not to play the vinyl; the second will be a musical and artistic interpretation of these soundscapes that reflects a new body of sound, amplified by numerous tiny speakers which inhabit the space.

The project Porto Sonoro⁵⁶, an archive of Porto sounds (project described in subchapter 3.1.9 - Porto Sonoro), was associated to this same festival and during these two years sound recordings for this archive were being made. As such all the sounds used in this facility were collected by the Porto Sonoro team or by myself to later be placed in the archive.

The installation operates in two modes:

- The automatic mode: where the sounds were used in small fragments played randomly in a way to imitate a “natural” soundscape.
- Vinyl mode: where, from these environments, two pieces were created and edited on one 10” vinyl (dubplate) with original illustrations by the artist José Cardoso⁵⁷(Figure 33). These pieces are in the Soundscape Composition category where, even processed and cut, the original sounds are recognisable and the pieces maintain a connection with the place of origin.



Figure 33 Vinyl labels. Illustrations by José Cardoso

The mode in which the installation was, automatic or vinyl, depends on the public interaction. After 10 minutes of inactivity, the system enters an automatic mode in which, between elevated periods of time, it plays small environments characteristic of the zone that blend with the natural sound. If the public interact with the installation by placing the vinyl on play, the installation enters vinyl mode.

⁵⁶ www.portosonoro.pt

⁵⁷ www.zecardoso.com

A familiar object like a turntable makes the relationship with the audience defiant in a public space. Without instructions on how to relate to the installation, the public decides whether or not to play the vinyl. At this point the automatic mode is paused for the piece to be played by a different set of speakers as the first set of speakers orchestrate/manipulate moments of the work in real-time. This whole process is made with a Max patch (Figure 34).



Vinyl Side B http://jasg.net/URB/SideB_snapshot.mp3 and Appendix B

4.3 Concerto X (Section)

Concerto X⁵⁸ is an 80 minute music piece created by seven composers in a close cooperation and with a conscious will to embrace aesthetic cross pollination. The aesthetic diversity was never a problem, being a conscious element to explore. For this study we will only focus in section B, with 9 minutes, as it is the part in which the creative process was focused on exploring our proposal for approaching soundscape data composition.

Formation:

- Tape (pre-recorded);
- Small orchestra: flute, oboe, bass clarinet, bassoon, french horn, trumpet, trombone, violin I and II, viola, cello, double bass;
- Improvisation ensemble: piano solo, violin solo and multi-percussion solo.

Tape/Soundscape (re)creation:

This work was commissioned to be premiered at the Vila Flôr⁵⁹ Cultural Centre in the city of Guimarães, Portugal. Knowing and starting from the premise of use, the soundscape as the main element for creating the music piece, the first action was to record the greatest possible amount of sound around the concert hall. After several days of recording at different times of various days (using a traditional sound map approach), we set the sounds that were repeated more frequently and which would be most representative of the place. We divided the sounds that were present in the recordings into three categories:

1 Keynote Sounds:

- Wind in the trees
- Fountain at some distance

2 Human Sound Signals:

- Footsteps on the gravel
- Footsteps on the concrete
- Children playing in the nearby kindergarten

3 Natural Sound Signals:

- Birds

⁵⁸ Premiered in October 2012 at Centro Cultural Vila Flôr, by Fundação Orquestra Estúdio under conductor Jean-Marc Burfin, with improvisers Carlos Zíngaro (violin) and Nuno Aroso (percussion), composers and improvisers Carlos Guedes, Filipe Lopes, Gustavo Costa, Pedro Rebelo, Rui Dias and two of the authors (Gomes e Penha) and live video by Kirk Woolford. Commissioned by Guimarães 2012, European Capital of Culture, Portugal.

⁵⁹ www.ccvf.pt

After isolating the sounds, with the fundamentals of the eco-composition principles in mind, we composed a new soundscape, combining them, respecting their functions, with the intention to recreate the local sound identity in a 9-minute track. This soundscape has a very simple structure formed by three small, interconnected parts: 1. Introduction: presenting the keynote sounds as a musical drone for the entire piece; 2. Development: adding footsteps creating a regular pulse; 3. Conclusion: all the previous elements fade out slowly and the birds and children sounds create a new sound ambient until the end. This reconstructed soundscape was the base for the rest of the work.

Orchestra:

The next phase of the process was to collect data with recognisable traditional musical characteristics, such as rhythmic, harmonic or melodic qualities that would be possible to use in the composition of the instrumental part.

The first action was to use the regularity of footsteps in the tape to set the pulse. As the place around the concert hall was a passing place, the footsteps caught on tape were very regular. We used two of them in loop to set a regularity in the beginning of the piece. The pulse was 129 bpm so we decided that the quarter note was equal to 129. Although it was a simple and direct solution it was quite important because with this resource we solved, for our case, a common problem in electroacoustic music with instruments. Furthermore, the relationship of time, meter and rhythm with the memory of physical movement was essential, especially regarding the relationship to the walk movement and synchronisation of physical activities such as marching, rowing, etc. As we have already explained this is particularly helpful for the director and the musicians to synchronise with the tape. As the piece does not have a particular measure, the score was written in 4/4 as a guide to follow and for rehearsal help. However this division was not arbitrary, because walking has a natural binary metric.

The second action was to use the keynote sounds material. The re-composed soundscape was very static with very soft oscillations and, because of the characteristics of the sound (wind and water), it was hard to detect pitch with a regularity that was interesting to orchestrate. However, there was pitch information that was varying along the piece time.

To separate the background noise from the relevant information we did a spectral analysis using the software Spear⁶⁰ developed by Michael Klingbeil. The analysis procedure is based on the traditional McAulay-Quatieri technique attempts to represent a sound with many individual sinusoidal partials, each corresponding to a single sinusoidal wave with time varying frequency and amplitude (Klingbeil, 2005). The analysis⁶¹ was done above the -35db amplitude threshold (we considered that below that was background noise).

⁶⁰ <http://www.klingbeil.com/spear/>

⁶¹ With the frequency resolution at 40Hz, window size: 4095 FFT size: 8192 and Hpo size:512.

Through the analysis it was possible to notice that there were 17 “groups” of pitch variation, spaced apart by lack of movement. Using the software Sonic Visualiser⁶², an open source application for viewing, analysing, and annotating music audio files (Cannam, Landone and Sandler, 2010), we analysed the key pitch for each group and polyphonic transcription in midi notes (Figure 35)



Figure 35 The analysis was made above the -35db amplitude threshold and the polyphonic transcription in midi notes respective midi conversion.

For each group, using the programming environment Max⁶³, we created a table of transition probabilities from one note to another (1st order Markov chain) (Figure 36). From this table of transition we generated a score where each table was only used to its corresponding time. For example the fourth table was a result of the analysis from 2.00 to 2.03, so the corresponding part in the score from this table respects the same temporal scope. The rhythm density was created freely according to the amount of notes. If a group had a low density of notes, the score generated had a corresponding density.

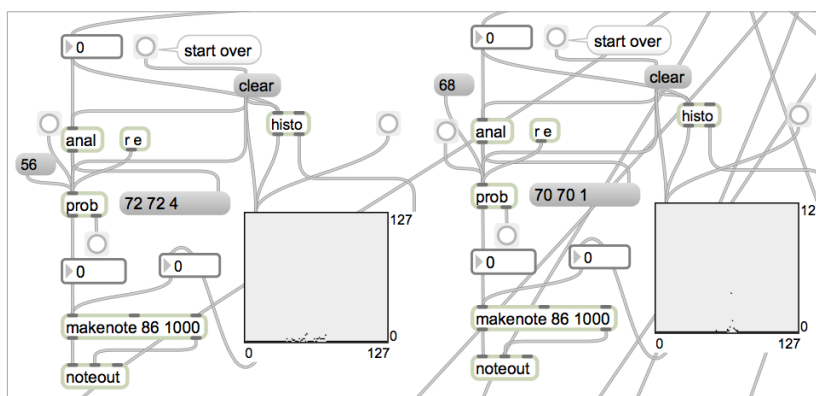


Figure 36 Extract of Max patch to create a table of transition probabilities from one note to another for each group – Appendix C.

⁶³ www.cycling74.com/products/max

⁶² www.sonicvisualiser.org

The notes generated were distributed respecting the natural range of the instruments. The keynote was applied to the double bass and the cello while the notes movement was distributed to the woodwinds (Figure 37). The same process was applied for the entire piece.

Figure 37 Extract of the orchestration of the soundscape

Improvisation ensemble:

The final part of the soundscape is with the sounds of children playing in the background and a strong presence of birds. For this final section we decided to explore this new element. The orchestra is fading out, with the sounds of wind, running water and the birds getting stronger. This last part became a duet between the birds and the soloists (percussion and violin) for that, we gather a group of 15 motifs, only the most compact ones to serve the motto function for free improvisation, from the *Catalogue doiseaux (Catalogue of Birds)* – XIII. Le Courlis Cendré from the composer Olivier Messiaen⁶⁴ (Figure 38). The choice of this reference to the work of Olivier Messiaen, was for the purpose of paying homage to one of the first composers who used nature sounds in composition

⁶⁴ Olivier Messiaen (born 1908, Avignon, France—27, 1992, Clichy, France), influential French composer, organist, and teacher.

with a systematic approach, although disconnected from any movement of soundscape or eco-composition. The motifs given are just a starting point for the improvisation accompanied by pre-recorded soundscape audio. There is no imposition of instrumentation or octave. It can and should be changed, repeated, varied, processed, and so forth. Improvisation should be like a dialogue/dispute between the two birds musicians, starting quietly and increasing tension and dynamic to the climax.



Figure 38 Extract of the motifs collected from the Catalogue d'oiseaux – XIII. Le courlis cendré for the improviser's section – Appendix C

Adding Gamelan:

As mentioned above, this piece described in detail here, is subsumed into a larger work composed for the creation and collaboration of various composers. As such, was crafted inclusion and unification of ideas, processes and aesthetic was crafted in order to achieve something more than a forced work collage of different composers. With this in mind, after the decision of several composers to include several pieces of a traditional Javanese gamelan, we decided to add the sound of the gamelan gongs in this section. As an aesthetic challenge, we decided to use the sound of the gamelan exactly with the same processes that we used with the soundscapes. This material starts at 2'16" after an introduction of the soundscape, until 8'11" at the same time of the fade-in to bird's section of the soundscape. The tape part is composed with a very slow sequence of low gongs. The rest of the analysis process is the same as presented above, using the software SPEAR and Sonic Visualiser. In this case we did not use the Max patch to generate a new melody. We orchestrated the information recollected directly from the gamelan's gongs because it was too rich and complex to make a counterpoint. This musical information was distributed to the remaining instruments: the brass section (Horn, Trumpet and Trombone), Viola, Violin I and II (Figure 39).

Figure 39 Extract of the score with the groups of orchestration

To conclude, the process was assigned to the pianist, which belongs to the improvisation ensemble, to take part in the gamelan part. So, from the previous analysis, a chord corresponding to the attack of gong was pointed out in the score. That chord is only a guide for the pianist to improvise during that section (Figure 40).

Figure 40 Extract from the chords guide for the pianist improvisation.

Full Score The full score can be found in Appendix C and www.jasg.net/concertoX_Soundscape_Score.pdf

Music File www.jasg.net/ConcertoX_Soundscape.mp3 and Appendix C

Tape file www.jasg.net/ConcertoX_Tape.mp3 and Appendix C

4.4 L'arbre des Songes

L'arbre des Songes⁶⁵ (The Tree of Dreams) is a six minute electroacoustic piece (tape) for a quadriphonic system. After the experiment of using the soundscape data in Concerto X, in this piece we decided to experiment with a more purist approach, creating a music work only with the data information taken from a random soundscape of a full day from an urban space also chosen randomly.

The data was collected from a window of our private house with a cardioid small diaphragm condenser microphone. Starting at 8 p.m. of December 15th 2012, the microphone was pointed to a regular street, with car and people traffic, during 24 hours. The date and place were selected randomly without any social, urban or sonic reason. That is exactly the main purpose: is a regular and innocuous urban soundscape a potential musical inspiration? During those 24 hours, using a Max patch (Figure 41), the sound was analysed using the Alex Harker⁶⁶ [descriptors~] object. This tool is used to calculate a large number of audio descriptors (or features) in real-time from an incoming signal

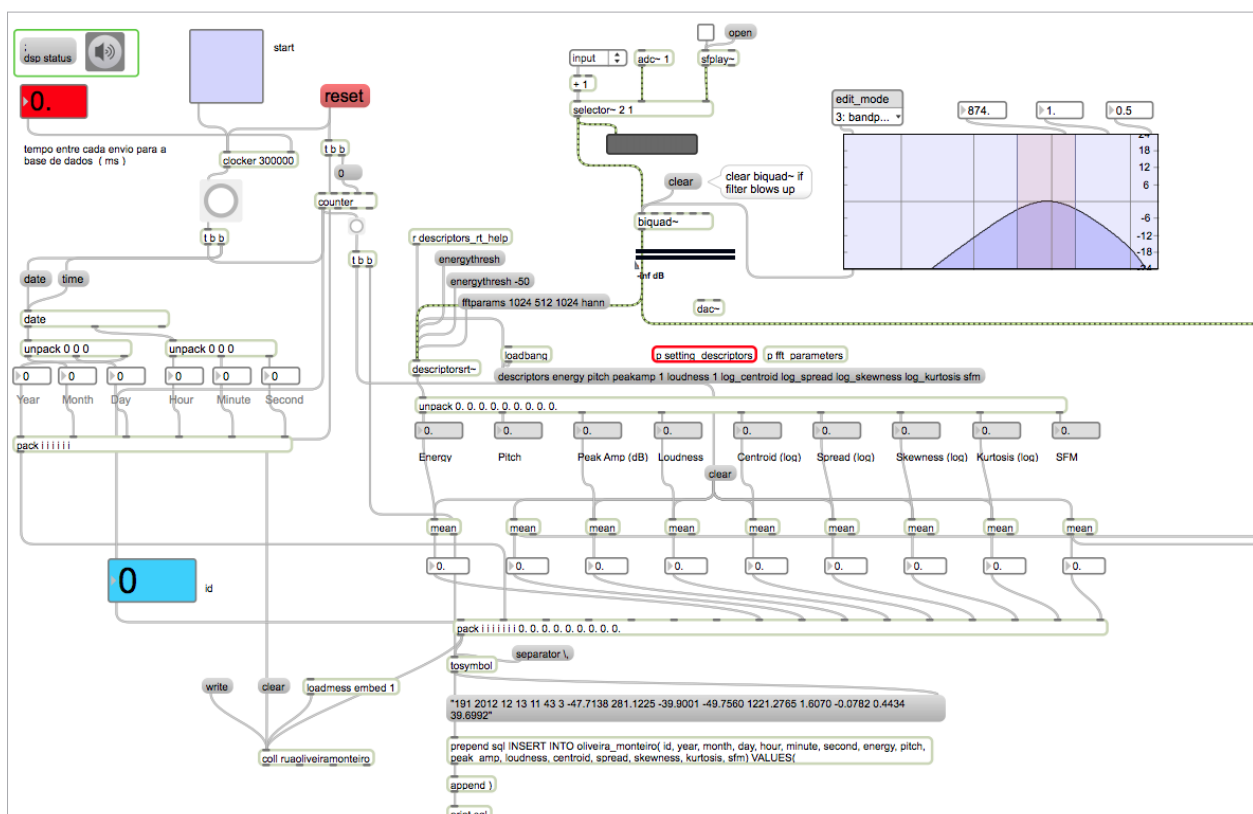


Figure 41 Max patch to analyse and collect soundscape data – Appendix D

⁶⁵ Premiered in December 2012 at SUONI INAUDITI - L'Auditorium Che Canta IV Rassegna Internazionale di Musica Contemporanea Auditorium Cesare Chiti, Livorno, Italy.

⁶⁶ <http://www.alexanderjharker.co.uk/> (accessed, November, 2012).

For each minute we save the mean of the descriptors values in a list (Figure 42).

```

1 1, 2012 12 0 0 19 53 0 -37.284161 285.946289 -29.417263 -38.337345 1398.753662 2.114615 -0.497845 3.932942 0.;
2 2, 2012 12 12 19 58 0 -36.907738 289.904358 -29.12084 -39.308121 1309.808716 2.119305 -0.507066 4.116416 0.;
3 3, 2012 12 12 20 3 0 -37.623035 293.296143 -29.861671 -39.800861 1358.219116 2.126251 -0.532549 4.325582 0.;
4 4, 2012 12 12 20 8 0 -36.666744 292.652069 -28.850681 -38.908207 1358.63916 2.130593 -0.534527 4.191643 59.811543;
5 5, 2012 12 12 20 13 1 -35.632553 292.035828 -27.994049 -38.946678 1240.224854 2.160274 -0.478973 3.931669 71.798401;
6 6, 2012 12 12 20 18 1 -35.324905 293.417114 -27.558939 -37.349018 1432.767944 2.104941 -0.655905 4.90867 64.636673;
7 7, 2012 12 12 20 23 1 -34.878384 295.691132 -26.990705 -36.4231 1487.728394 2.042615 -0.696649 5.405661 38.252064;
8 8, 2012 12 12 20 28 1 -37.376392 297.845306 -29.615637 -39.695591 1398.863037 2.102901 -0.600614 4.855707 34.261227;
9 9, 2012 12 12 20 33 1 -37.744736 290.52533 -30.056513 -40.515362 1293.014771 2.158836 -0.492312 3.986478 31.476803;
10 10, 2012 12 12 20 38 1 -38.549107 293.29245 -30.946779 -42.084507 1172.795532 2.229767 -0.406655 3.354855 27.907198;
11 11, 2012 12 12 20 43 1 -39.430744 289.877136 -31.856808 -42.546829 1226.209106 2.194553 -0.426791 3.674617 31.204239;
12 12, 2012 12 12 20 48 1 -39.211094 289.392303 -31.638756 -43.014076 1136.955444 2.245692 -0.412929 3.332951 26.9048;
13 13, 2012 12 12 20 53 1 -40.584255 290.83725 -33.175167 -44.865555 1082.91333 2.284865 -0.324366 2.83741 25.619444;
14 14, 2012 12 12 20 58 1 -38.839863 287.589233 -31.187622 -41.817139 1204.80249 2.171877 -0.415668 3.573013 31.713028;
15 15, 2012 12 12 21 3 1 -42.045879 292.93045 -34.760418 -46.98317 1013.421936 2.336931 -0.293644 2.654188 23.28541;
16 16, 2012 12 12 21 8 1 -40.423576 287.245239 -32.966927 -44.717625 1092.228882 2.270525 -0.322294 2.92321 24.340925;
17 17, 2012 12 12 21 13 1 -38.965195 288.558746 -31.522781 -43.155628 1071.97644 2.230339 -0.371552 3.22593 26.805998;
18 18, 2012 12 12 21 18 1 -40.478439 292.527954 -33.19717 -46.210583 919.757812 2.318158 -0.271041 2.514517 19.861599;
19 19, 2012 12 12 21 23 1 -40.30241 289.812653 -32.959404 -44.913303 1026.869629 2.278869 -0.328559 2.895215 24.695721;
20 20, 2012 12 12 21 28 1 -42.373653 294.13562 -35.279541 -48.36359 910.728271 2.431193 -0.260851 2.261236 19.57169;
21 21, 2012 12 12 21 33 1 -40.858246 290.275726 -33.486389 -45.801987 967.724976 2.29771 -0.293523 2.691055 23.777826;
22 22, 2012 12 12 21 38 1 -40.609779 288.836853 -33.242016 -45.334774 984.958435 2.246135 -0.315979 2.928432 24.920645;
23 23, 2012 12 12 21 43 2 -40.566004 292.330261 -33.297634 -45.681877 962.330688 2.327629 -0.287529 2.55848 22.103533;
24 24, 2012 12 12 21 48 2 -42.228607 290.253418 -34.949303 -47.229404 968.127258 2.345569 -0.2624 2.427569 21.720547;
25 25, 2012 12 12 21 53 2 -41.80357 292.87088 -34.509983 -46.81979 955.671631 2.322974 -0.272282 2.553775 23.279436;
26 26, 2012 12 12 21 58 2 -42.885937 290.356812 -35.637409 -47.914082 937.019165 2.34882 -0.24968 2.363373 21.595146;
27 27, 2012 12 12 22 3 2 -41.875671 287.3992 -34.546726 -46.824989 957.545959 2.312517 -0.27413 2.60587 22.872374;
28 28, 2012 12 12 22 8 2 -42.648621 290.578156 -35.389317 -47.822418 962.542114 2.360013 -0.258158 2.411078 21.439823;
29 29, 2012 12 12 22 13 3 -42.261059 292.140411 -34.938221 -47.267632 969.026611 2.335475 -0.287594 2.609498 22.800291;
30 30, 2012 12 12 22 18 1 -41.030315 290.59137 -33.641399 -45.349976 990.59082 2.268644 -0.290872 2.746213 24.732609;
31 31, 2012 12 12 22 23 1 -38.853203 296.555969 -31.221979 -42.203312 1095.802124 2.282079 -0.377229 3.042587 26.816755;
32 32, 2012 12 12 22 28 1 -41.455673 294.930725 -33.989212 -45.499954 1024.97937 2.354693 -0.287637 2.470113 23.453379;
33 33, 2012 12 12 22 33 1 -41.786953 292.704529 -34.153629 -44.756451 1281.291992 2.244289 -0.419393 3.605059 28.364674;
34 34, 2012 12 12 22 38 1 -41.636375 298.164917 -34.020107 -44.54018 1280.345459 2.248369 -0.42482 3.688052 29.914495;
35 35, 2012 12 12 22 43 1 -42.252316 301.43042 -34.678383 -45.622795 1235.434937 2.291373 -0.362952 3.294549 27.342495;
36 36, 2012 12 12 22 48 2 -42.454662 296.709534 -35.013634 -46.976574 1104.38562 2.357189 -0.318767 2.867399 23.5567;
37 37, 2012 12 12 22 53 2 -41.305111 304.263 -33.792667 -45.574749 1128.473267 2.326638 -0.323651 2.764557 22.720276;
38 38, 2012 12 12 22 58 2 -41.949562 294.752625 -34.571575 -46.328068 1104.565063 2.341431 -0.338613 2.922388 23.581436;
39 39, 2012 12 12 23 3 1 -41.708244 292.551239 -34.299419 -45.80365 1128.398438 2.276612 -0.344146 3.140105 25.764404;
40 40, 2012 12 12 23 8 1 -41.433022 287.594116 -33.847126 -44.801003 1183.373535 2.225354 -0.370533 3.347063 29.165754;
41 41, 2012 12 12 23 13 1 -43.13969 289.820038 -35.74781 -47.630432 1050.354004 2.343029 -0.280192 2.568848 23.674463;
42 42, 2012 12 12 23 18 1 -42.852371 289.423279 -35.575333 -47.896397 1007.226013 2.392882 -0.242413 2.212128 20.755651;
43 43, 2012 12 12 23 23 1 -41.472713 290.65274 -34.014061 -46.079712 1042.785156 2.275297 -0.311141 2.881042 25.082872;
44 44, 2012 12 12 23 28 2 -43.460865 292.432434 -35.997902 -47.225803 1163.477295 2.332335 -0.315807 2.857503 24.314636;
45 45, 2012 12 12 23 33 2 -43.592873 297.354248 -35.88324 -46.50359 1315.146118 2.287806 -0.393803 3.53682 27.149534;
46 46, 2012 12 12 23 38 1 -43.145306 294.063049 -35.668449 -46.973061 1211.010498 2.342751 -0.353406 3.103962 26.97036;
47 47, 2012 12 12 23 43 1 -43.315296 291.825409 -35.730499 -46.405556 1267.869385 2.277778 -0.345843 3.220161 27.744267;
48 48, 2012 12 12 23 48 1 -43.325367 291.728577 -35.953018 -47.434063 1125.498535 2.336896 -0.312339 2.849863 25.65937;
49 49, 2012 12 12 23 53 1 -44.535694 291.813477 -37.177944 -49.192291 1082.176514 2.416517 -0.258102 2.374841 22.866978;
50 50, 2012 12 12 23 58 1 -42.010658 292.939789 -34.727837 -46.794815 1015.957458 2.340351 -0.285488 2.609873 23.076019;
51 51, 2012 12 12 0 3 2 -43.669159 290.541351 -36.277927 -47.779972 1085.080566 2.334777 -0.298197 2.781956 26.222492;
52 52, 2012 12 13 0 8 2 -42.115784 294.413849 -34.663788 -45.890772 1143.719238 2.312334 -0.336636 2.939286 26.230988;
53 53, 2012 12 13 0 13 1 -42.970154 289.127991 -35.559296 -47.058331 1059.415161 2.320453 -0.2877 2.641858 25.841385;
54 54, 2012 12 13 0 18 1 -44.338879 293.07196 -37.206333 -49.587452 967.715515 2.428387 -0.257392 2.391844 22.79089;

```

Figure 42 Sound descriptors extract list.

Composition:

The first process was to transform that information of a 24-hour soundscape and read it all in 6 minutes. Then we used the pitch sound feature information to control a simple oscillator. The resulting track was assigned to the function of background sound for the whole piece. The frequency was always around C#3 to D3. During the night the frequency was higher and more stable, which was found to be related to the street lamps that produce a tone while they are working.

The second step was to use a very basic random midi note generator with only three variables: low limit, high limit and note density. The notes range was controlled by the combination of the centroid and spread features (that gave us the spectral centre and its limits), and the loudness feature controlled the density.

This technique is related with the Barry Truax approach. He uses granular synthesis as a device in his research of acoustic ecology and soundscapes. Truax composed using granular synthesis to stretch

sound events, enabling the listener to hear the multitude of sounds and characteristics present within the event (Truax, 1990, 1992). In this case we do not expose the sound characteristics but we use them, as descriptors, as high-level controls of a granular synthesis process.

The result was quite self-explanatory. During the evening, the range was large but without much density (still movement in the street but not too much), during the night the notes were in the low region and widely dispersed. When the day begins the range increases to the maximum and the density becomes much higher, especially in the early morning that corresponds to the time of the day that most people go to work (Figure 43). The spatialisation was improvised in real time.

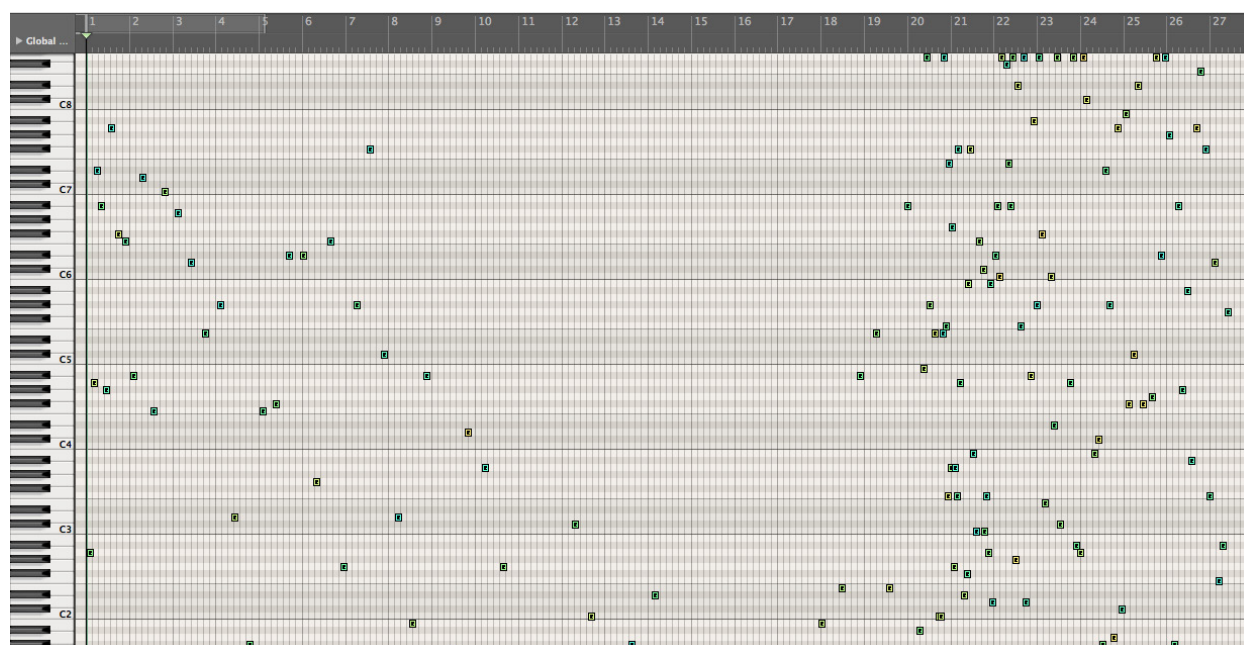


Figure 43 MIDI score created by soundscape features.

In a reviewed version of the piece a sound of a squeaky door hinge of an old church from the same city was added; Sound performed and recorded by the sonic artist Gustavo Costa⁶⁷ for a sound library of Porto⁶⁸. The introduction of these sounds reveals itself as an interesting counterpoint of a different use of sound identity in the same piece with a musical citation from one of the sonic artists that has been most prominent in the identification and cataloguing of the local sonic identity. (The use of this citation is an homage to the author)

L'arbre des Songes (*stereo version*)

www.jasg.net/Larbre_des_songes-stereo.mp3 and Appendix D

⁶⁷ www.gustavocosta.pt/

⁶⁸ www.portosonoro.pt/recolhas/ressonancias/ (accessed, November, 2012).

Project described in subchapter 3.1.9 - Porto Sonoro.

4.5 PORTOphone

The work presented next, contrary to the previous ones, is not a pure artistic creation but an illustrated sound map in an app for smartphone format. We decide to present it because we believe that the experience gained in this project, to crystallise the soundscape of a city in a single tool, is useful for the development of the proposal and the project.

PORTOphone is an iOS music application that enables the use of Porto sounds in a musical way, making a combination of illustrations of the city's iconic locations with sounds recorded on site. In addition to the environment sounds, the PORTOphone also allows you to hear a set of peculiar and typical oral expressions recorded in the oldest areas of the city. With this tool we can create our own soundscape from the sounds of the city of Porto. This application was curated and developed at Digitópia Casa da Música⁶⁹.

This app was developed from the computer version developed by Filipe Lopes⁷⁰. PORTOphone makes use of Porto sounds through a creative interface. Musical clock carillon from Santa Catarina Street, trading sessions in Bolhão Market, the crosstalk of passers-by in Batalha Square, the traffic in the streets or the birds of the City Park are some of the audio recordings in PORTOphone, which join small testimonies and expressions about life in Porto collected from anonymous citizens. The interface, designed by Maria Monica, reveals an illustration of Porto where we can go visit the various sounds, exploring their mixtures and creating in real-time (Figure 44). More than identifying this or that sound, the user is challenged to build, from what they hear, their own sound composition, reinventing the voice of Porto. Each time that you use the on/off switch each point is loaded with a new sound collected from that place, enabling to recreate a new Porto soundscape.

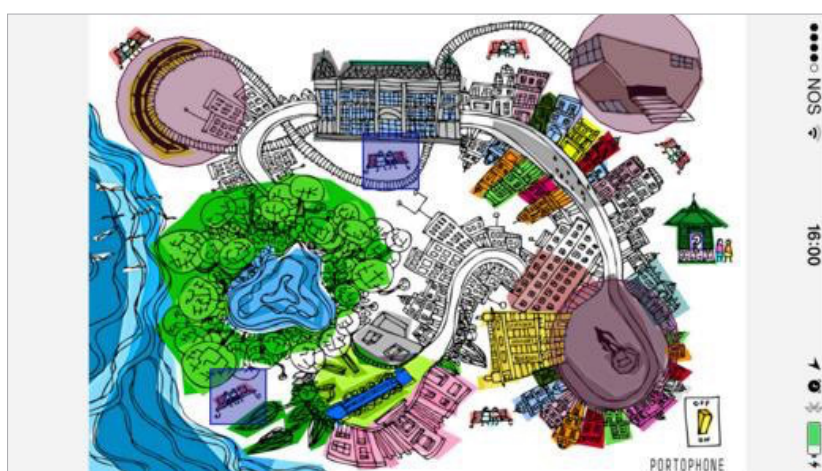


Figure 44 PORTOphone application interface

⁶⁹ Digitópia is a digital music platform based at Casa da Música in Porto, which encourages the act of listening, performance and musical creation. Based on digital tools, although not exclusively, Digitopia emphasises collaborative musical creation, software design, music education, social inclusion, aiming to emerge multicultural communities of performers, composers, curious people and music lovers. www.casadamusica.com/digitopia (accessed, August, 2014)

⁷⁰ www.filipelopes.net

The places represented in the application are: Casa da Música (concert hall), Bolhão Market, Metro stations, the City Park, Serralves Gardens, Batalha Square and Santa Catarina Street (shopping area). We believe that these emblematic places, and their sounds, together create a representative image of Porto identity. In addition to the environment sounds, clicking in the park benches, the PORTOphone also allows you to hear a set of peculiar and typical expressions recorded in the oldest areas of the city.

The recordings were made with different techniques. The open air areas were made with the zoom H4n recorder using a xy technique, the testimonies with a shotgun microphone and the conversions and small areas with binaural microphones (a less invasive technique and providing a more realistic spatial experience to the listener).

Development team

Conception: Filipe Lopes

Illustration: Maria Mónica

iOS coding: Óscar Rodrigues

Sound recordings: Filipe Lopes, José Alberto Gomes and Porto Sonoro⁷¹ project

Sound edition: José Alberto Gomes

App Store Link

<https://itunes.apple.com/WebObjects/MZStore.woa/wa/viewSoftware?id=903671821&mt=8>

4.6 Chapter Conclusions

The main purpose of this chapter is to share and describe, in detail, different approaches to music composition using the soundscape material.

The works presented can be divided into two different groups:

- Projects that work with the sound recordings,
- Projects that work with the soundscape raw data.

The first group was an important artistic experience and an important way to develop a contact with the practices and principles of soundscape composition. They were also a very important background and progress to achieve the first ideas and approaches to the eco-structuralism experiences.

This is the case of the work *Antonomásia_O Porto*. Although not having a direct relationship with the approach developed later, the experience during its development was the starting point for the

⁷¹ www.portosonoro.pt/ (accessed, November, 2013). Project described in subchapter 3.1.9 - Porto Sonoro.

formulation of the idea. This work was fundamental to understand and develop the artistic and conceptual need to use the soundscape beyond their direct use in the final work. The same applies to the experience gained in the project *PORTOphone*. The process of collecting and mapping the soundscape of Porto was crucial to understand the importance of this approach regarding geographical and social characteristics, but also to promote interest in implement other elements of the soundscape, especially their evolution over time on a large scale.

In the second group there are the main conclusions and the more relevant explanations for this research. In both works we believe that the use of this material did not compromise the artistic outcome. Quite the contrary, we believe that due to this eco-structuralist approach, we could achieve a conceptual coherence and closeness among art, public and sonic identity of a place. A secondary purpose is to conclude the relevance of this approach. In the *Concerto X* approach, regardless of personal preferences or artistic quality, we can state that, besides the use of soundscape data, the piece managed to maintain an identity coherence and mimetic proximity to the original soundscape, but in this case we still directly use the soundscape and we reorganise the elements to fit into the music work's time scale. In the *L'Abre des Songes* approach we just used the soundscape data, not making any direct reference to any sonic identity, while respecting proportions and structures. As a result of this experience, we believe that it is safe to conclude that soundscape data has potential material for use in the artistic creation.

The role of colour or timbre would be completely changed from being incidental; (...) it would become an agent of delineation, like the different colours on a map separating different areas, and an integral part of form.
(Varèse, 1936)

As Varèse (1936) and Schoenberg (1978) predicted, timbre has become a dominant element in composition (as we can see in the excerpt above). Specifically with the emergence and emancipation of aesthetic relating to electro-acoustic music or movements like spectralism. Technically, before these two experimental works, we concluded that the use of timbre in composition, like spectralism or high level of synthesis control, granular or not, had a deep proximity to a compositional approach to soundscape composition. This is especially true, if we work in a soundscape composition context without directly using the sound in the final work. As such, the timbre, structures and patterns in the time domain, are the richest musical elements to provide content to a creative activity, which although within an abstract art, intends to keep a close reference to its source element.

Chapter 5

Research Methodology

In this chapter we start by describing the overall research approach used throughout our study. The methodology used to assess the experimental system we developed to analyse and capture urban soundscapes data and to provide access to that information is presented in detail⁷².

5.1 Analysis and Comparison of Research Procedures and Methodologies of Science and Art

Different sciences have different methodologies and techniques, and a consolidated methodology and terminology are fundamental factors for the creation of knowledge. As such, the lack of proper and own procedures leads researchers in Art to use those that have been established in Science and Social Sciences. According to Gray and Malins, such appropriation has led to two situations:

- *Being forced to adapt (preferably) or (more commonly) borrow a ‘standard’ methodology, which may distort the research;*
- *Or alternatively, taking the risk of inventing esoteric methodological devices/tools, which may remain so project-specific to be of little, if any, use when applied to other situations.* (1993, p.3)

It is therefore clear that artistic research demands an appropriate set of procedures and methodologies according to the characteristics of the discipline, but as in the Sciences and Social Sciences, equally rigorous, respectable and accountable.

As pointed out before, the research methodologies adopted, will reflect the specific nature and intentions of the discipline. Therefore, to contextualise the procedures applied in our research, we think that it is pertinent to briefly examine the characteristics of existing methodologies:

Scientific Models: Classical Mechanics/Newtonian Science

In general, the aim of science is to provide explanations for phenomena. Determinism in the West states that the physical matter of the universe works according to a set of fixed, knowable laws. In this scientific perspective the research strategies are characterised as systematic, rigorous, controlled, deductive, predictive, empirical and based on logical experimentation. (Gray and Malins, 1993).

⁷² In the academic area, research methodology is a set of procedures and stages completed systematically to find the solution for a scientific problem. There are standardized techniques shared and accepted by the scientific community, in order to ensure the reproducibility of results when all the original conditions are replicated. Equally important, this group of procedures exposes and quantifies the systematic errors that exist in the “problem” at hand.

Scientific Models: Quantum Science

At the beginning of the Twentieth Century, scientists acknowledged the limitations of the reductionist approach to respond to certain subjects (Capra, 1983). In the development of quantum theory, subjectivity, observer's perceptions, simultaneity, relativity, uncertainty, randomness, indeterminacy, subatomic anarchy, chaos are now concepts present in the scientific approach and research strategies (Gleick, 1997).

Social Sciences Model

The social sciences, just as education, sociology or anthropology, rely in the value of context, and the importance of the perceptions of the researcher. Initial reliance on the Newtonian Science methodologies, quantitative in nature, did not provide proper tools for social subjects, like culture, behaviour, people, and so forth. Qualitative methodologies, developed for these non-deterministic contexts and disciplines, appear valuing the subjectivity, individuality, complex interaction, involvement, among others, and are now considered legitimate procedures (Gray and Malins, 1993).

5.1.2 Science and Art

Although research in Art and Design is relatively recent, procedures and methodologies in a practical context in the visual arts have been articulated (Allison, 1991). Art history and contemporary critique provide rich sources of information on creator's processes.

Similar Processes

Art and Design procedures share some basic structure for practice and, according to the biochemist and sculptress Gillian Russell, it is possible to find parallels between the procedures adopted in art creation and the methodologies involved in structuring scientific research. Even though their contexts and purposes can be different, processes involved in creativity, science and social science present similar factors (Table 2) (Gray and Malins, 1993).

Science		Art
hypothesis	urge to create	initial inspiration
collect data	generation of ideas	reflection
definition of problem	selection and classification	analysis
development	models/sketches/experiments	field work
illumination	synthesis	articulation
refinement	resolution	presentation
verification	testing/theory building	generalisation
critical context		human response
revise hypothesis	alter concepts	improve artwork

Table 2 Similar factors involved in creativity, science and social science

Differences: Generality/Replicability - Uniqueness/Originality

It is in the differences between these two areas of methodologies and processes where the lack of tools becomes clear.

The main criticisms (from a classic scientific perspective) of artistic 'method' focus on the lack of objectivity and the often idiosyncratic nature of the work, perceived as often lacking rigour. (Gray and Malins, 1993, p.12)

Generality (the ability of study the particular and apply this to the general) in science is a rather tough concept to apply to art research. Therefore, the uniqueness/originality required in an artwork, is not easily reconciled with the concept of generality. Replicability, although a theory that may be derived from practice and repetition, is also antagonistic with the concept of singularity.

Research Confirmation

In the art research model, unlike the science model, confirmation and verification presents some difficulties. Confirmation may come from others working in the same field, however, this is far from being categorical confirmation but might only reinforce or refute, the value of the practice, theory or work. This review is processed mostly through the cyclical process of critical examination, rechecking and refining when the work is exposed. It is not unusual that different groups, like critics and the public, do not share the same conclusions. Even the same group develop different opinions over the same practice or work over time.

According to Allison (1991) the more complementary research methodologies to the artistic method are:

- Descriptive (surveys, causal-comparative methods);
- Naturalistic (interpretative, phenomenological, qualitative enquiry);
- Practical (creative, expressive/productive);

while the research methodologies that gained acceptance in the wider context of research are:

- Historical
- Philosophical (theoretical)
- Experimental (pre/post testing)
- Comparative (cross-cultural)

If still appropriating from the scientific methods these provide a useful window to structuring artistic research and, to the extent possible, to obtain validation.

5.2 Towards and Interdisciplinary Methodology

Sound and Music Computing (SMC) research approaches the whole sound and music communication chain from a multidisciplinary point of view. By combining scientific, technological and artistic methodologies it aims at understanding, modelling and generating sound and music through computational approaches [...] Artistic methodologies refer to approaches that explore human experience and expression. (Serra, Leman, & Widmer, 2007, p.9)

On the roadmap for SMC 2007⁷³, the value of the interdisciplinary research that characterises within this field of research is presented quite clearly. It is argued that, to have a truly comprehensive study, the subjective factors play a central role in how people deal with technology (Serra, Leman, & Widmer, 2007). It is argued that this interdisciplinary approach fulfils the gap between our daily and emotional (qualitative) experiences with sound and music and the physical energy of sound and music that deal with quantities.

The methodology employed in our research, both designing and evaluating the prototype system URB, follows a user experience evaluation approach to find what satisfying in particular, from a subjective first-person perspective, in line with qualitative attempts of evaluation.

We do this through having a group of artists working with our proposed concept and provide questionnaires and conduct interviews to find out about the needs and motivations of users using URB; Firstly to determine the quality in a technical perspective of a user of the experience, and afterwards some artistic and emotional indicators.

⁷³ The Sound and Music Computing (SMC) Conference is the forum for international exchanges around the core interdisciplinary topics of Sound and Music Computing. The conference is held annually. www.smc-conference.org

A research process is a methodological resource that represents a way to collect data regarding the variables participating of that phenomenon, to be analysed at the end in order to draw conclusions. From the social sciences perspective, there are three main groups of research tools:

- **Experiments:** Usually a laboratory test where most of the variables are kept under control. An experiment is able to provide great internal validity.

However, real-world applications are sometimes hampered by the lack of real and more complex settings in the controlled environment;

- **Surveys:** (one of the most common tools used in social sciences research) Closed questionnaires can produce numeric (quantitative) data and are more easily compared with each other, while interviews require a linguistic analysis and tend to produce more qualitative data;

- **Ethnography:** A methodology based on the observation of individuals in their natural habitat. In this case the scientist has no control over the variables. These studies tend to have more external validity.

These tools are only effective if applied in groups or samples that are representative of a broader population.

Our preliminary research, described in Chapter 4 - Preliminary Experiments On Soundscape Composition, can be linked to the laboratory experiments where real-world settings are tested and simulated. In our main research, the methodology was based on the development of a system, which artists use in their creative process. This system is our main research tool, providing us with a context for surveying the users. It is important to refer that in research of this nature, we are not searching for a true and universal solution to a precise problem, but instead give artists the opportunity to experience their sound environment and technology in novel ways and assess their feedback. As a result we hope to get valuable inputs for future models and theories.

To structure our research, we find it useful to apply the five categories presented in the first stage of framework for experimentation in software engineering (Basili, Selby, & Hutchens, 1986):

- **Motivation:** Our main research motivation is to better understand how urban soundscapes can be captured and used in art creation, and if that is useful and meaningful.

- **Object:** The object of the study can be described as a model of interaction between the soundscape and the user.

- **Purpose:** The purpose of the study is to gather knowledge from divergent disciplines with the

final goal of motivating, in an exploratory way, forthcoming theories and frameworks on the topic of soundscape composition and soundscape ecology.

- **Perspective:** We approach the study from a researcher point of view. Our goal is a research tool and not at a final product.

- **Domain/Scope:** The domain and scope are restricted to the research project, the system to analyse and capture urban soundscape and the artistic interaction with that data.

5.3 Methodological Procedure

We will now describe the methodological procedures of the experimental part of our study; the design, development and implementation of a system that can analyse and capture the surrounding soundscape (described in detail in Chapter 6 – URB: Prototype System for Experimental Research).

Our approach is through a user experience study in line with the qualitative attempts of evaluation. We do this by having a group of artists based on the URB system, and provide questionnaires to find out about the needs, motivations and impressions of the users.

5.3.1 Subject Selection

The first step was the selection of a sample of subjects to participate. In order to ensure external validity, the sample had to be representative of the population to who the study concerns. In practice, as afore mentioned, research with the characteristics like ours always requires a certain amount of compromise, and the constraints. The requisites for people to be selected as subjects of the sample were:

- **Artistic Background Sonic Arts:** We focused on people who already have a deep contact with the artistic and creative process and with the concepts of originality and critical approach in art.
- **Artistic curriculum with recognition in the community:** In order to reach generalizable results, with all the difficulty, which that means in artistic research, the participants had to have a certain level of peer recognition prior to this experience.
- **Know the basic principles of soundscapes movement:** Whilst not wanting to reduce this experience only to the soundscape community, running the risk of limiting the conclusion to one

point of view, it is essential that the participants know the essential principles and concepts of the soundscape movement and soundscape composition.

- Volunteer participants: No payment was ever involved. Only the artistic work and creation should be the motivation to participate.
- Willing to share the creative process and work: Not all artists are willing to share their creative processes or to publicly submit their critical conclusions, just as many are not willing to open their works to an open license. However, these three premises are critical to the clarity of this experience
- Diversity: Respecting the previously presented points, it is quite important that the participants are heterogeneous in their artistic characteristics in order that conclusions may be drawn from here, also as universal as possible in this kind of research.

5.3.2 Test Groups

Taking into account the constraints mentioned in the previous point, a challenge was made to the musical and sound art community to work on using URB in the creative process. It could be an electro-acoustic piece, music for instruments or a sound installation. The only requirement was that somehow the data from URB had to be used in the composition of the work. Several artist from different backgrounds and with different aesthetic purposes responded to the challenge.

Limited to the presented requirements and to the long process, energy and availability inherent to the participation, the test group was formed by 8 subjects, which developed worked based on URB, described in detail in the Chapter 7 - URB artistic applications, and participated in a quantitative and qualitative questionnaire, described in detail in the Chapter 8 – System Evaluation and Result Analysis. The author of the thesis was part of some artistic experiences described in the chapter 7 but did not fill in a questionnaire.

Chapter 6

URB: Prototype System for Experimental Research

In this chapter, the design and development of a system to capture, analyse and store urban soundscapes is presented in detail. A prototype system for experimental research on the topic of Composing with Soundscapes: Capturing and Analysing Urban Audio for a Raw Data Musical Interpretation that we named URB. We also present an experimental application to enable the data consultation and facilitate the process for the transposition into the creative processes.

Note: Since it is not our area of expertise, part of the technical material presented in this chapter was developed in collaboration with Diogo Tudela and some anonymous online community in order to implement in most effective way the concept developed by us.

6.1 System Overview

URB is a system for automated analysis and storing of an urban soundscape. It complements traditional sound maps, allowing the direct access of the soundscape features at any arbitrary moment from the system's boot, thus facilitating the study of the soundscape evolution and the differences between specific timeframes, and facilitating artistic approaches to such data. It is based on available and cheap hardware and open source software. Thus, it may be a tool with a very large curve of development and flexibility to be used by artists with creative intentions, but also by environmentalists and urban planners.

The implementation of the project is divided into four stages:

- Hardware & Software - Design, prototyping and development of a listening point and database;
- Installing four listening points in the city of Porto;
- Design, prototyping and development tools to access the database;
- Turning the project, database and the software public.

The system is composed of four listening points that capture and analyse the soundscape, a database with the features of the sound and tools to access and consult the database (Figure 45).

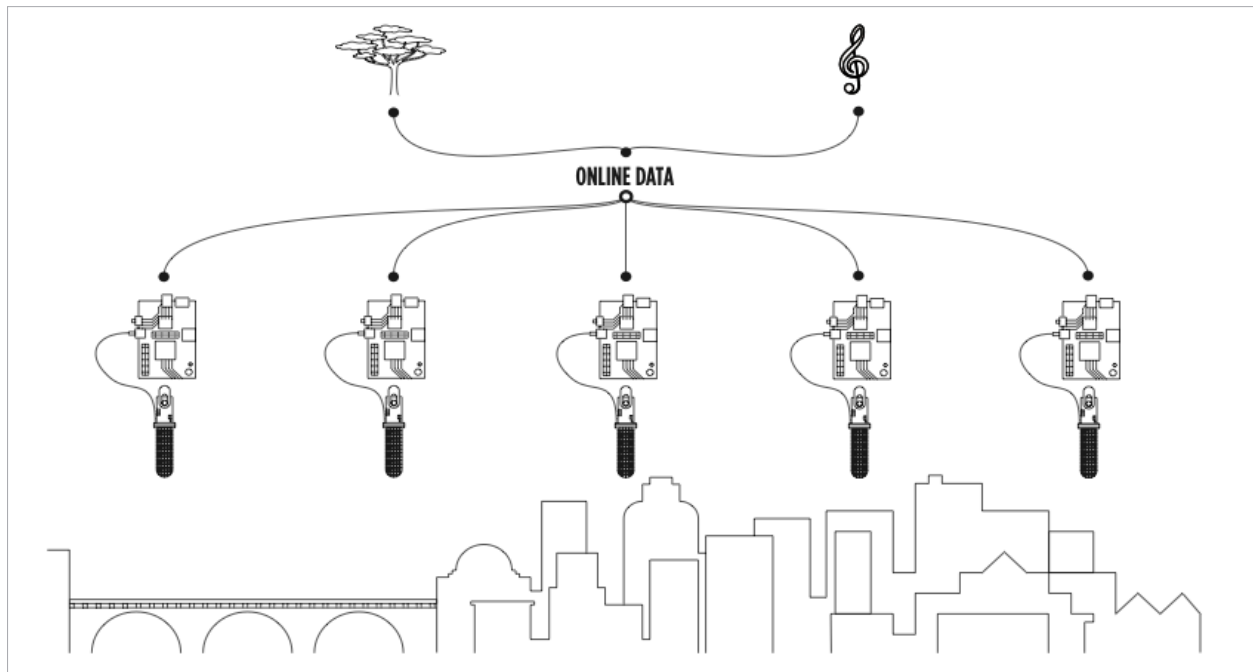


Figure 45 The three phases of the URB System: capture and analysis system, database with soundscape features, tools to access the data.

6.2 Conceptual Framework

As presented in Chapter 3, the notion of soundscape is increasingly relevant not only in contemporary culture and acoustic ecology, but also in many other fields, such as artistic productions. The paradigm now is that the research of soundscapes is becoming less and less about physical measurements but in the cooperation of human/social sciences field. The environmental sounds being treated ever more as a *resource*.

The first challenge in working with soundscapes is how to capture and represent them in a way that they are representative of a geographical and cultural space and time. With the development of studies and sound collections, like the freesound project, and portable memory-based recorders being so inexpensive, sound maps have become increasingly common. Usually the sound maps are based on the geographic origin of the recordings. However, as Barry Truax identified, *lacking any coherent temporal perspective* (2012). The first challenge was to work on this problem. As such, the main purpose of this proposed system in the capturing field is that complements (and does not replace) traditional sound maps, allowing the direct access of its features at any arbitrary moment since the system's boot. Then facilitating the study of the soundscape evolution and the differences between specific timeframes, and facilitating artistic approaches to such data.

Our research is not only about the soundscape capture and study, but of it uses in music creation. The use of soundscapes in composition is quite widespread but relies mainly in the direct use of the

sound. This approach is not the only one and, as shown in Sub Chapter 2.7 - Eco-Composition and Eco-Structuralism, the inside structure and time behaviour of soundscapes can be a very rich and relevant artist source. Although this practice is recent, it already presents solid principles and proven artistic applications. We decide to follow this approach, enriching our system with several approaches to how artists can consult or access the data to be used in their creations.

6.3 Listening Points - Urb-Box

6.3.1 Hardware

The Locustream sound map, subchapter 3.1.7 - Locustream Sound Map & Locustreambox has a very interesting approach to soundscapes, but still has the time problem. To support the project, they developed an autonomous *LocustreamBox* - a small computer dedicated to the task of streaming audio and configured to connect automatically to their server and related systems such as online interfaces or setups for installations. This small computer proved to be a huge inspiration and example for the development of our system.

Raspberry Pi

The first approach to the microcomputer choice was analysing the Locustream Box. They used a PC Engine 500 MHz AMD Geode LX800 using Gentoo Linux distribution⁷⁴.

This hardware was sufficient for what we needed. The problem is that it would be necessary to order the different parts and put them together, plus the total cost was around 150€. For us this seemed to be a major problem to a project that wants to grow spontaneously under the individual motivation. The Raspberry Pi is a credit-card-sized single-board (Figure 46) computer developed in the UK by the Raspberry Pi Foundation with the intention of promoting the teaching basic computer science in schools. It has an ARM1176JZF-S 700 MHz processor VideoCore IV GPU, and 512 megabytes of RAM. It does not include a built-in hard disk or solid-state drive, but uses an SD memory card for booting and long-term storage⁷⁵.

⁷⁴ “<http://locusonus.org> - Locus Sonus WiKiLab - Locustream Streambox.” [Online]. Available: [http://nujus.net/~locusonus/wikis/?page=Locustream Streambox](http://nujus.net/~locusonus/wikis/?page=Locustream+Streambox). (Accessed: 26-Mar-2013).

⁷⁵ “<http://locusonus.org> - Locus Sonus WiKiLab - Locustream Streambox.” [Online]. Available: [http://nujus.net/~locusonus/wikis/?page=Locustream Streambox](http://nujus.net/~locusonus/wikis/?page=Locustream+Streambox). (Accessed: 26-Mar-2013).



Figure 46 Raspberry Pi Model B - (<http://www.raspberrypi.org>)

The Raspberry Pi presents a solution for most of our needs. It is quite cheap, it is already built, and it has a very enthusiastic community working to develop the hardware and system; most of them, around the Pure Data on Raspberry Pi, a fundamental tool for our project.

USB ADC

The Raspberry Pi does not have an analog input, a USB sound card is necessary. Not all the USB Analog to Digital Converters (Figure 47) work with the Raspberry Pi and it is important to slow down the device speed to 1.1 adding

```
$>> dwc_otg.speed=1
```

to the string in the file `/boot/cmdline.txt`⁷⁶.

As we are only using the computer as a listening point, we change the USB ADC to default changing the `/etc/modprobe.d/alsa-base.conf` file replacing the

```
$>> options snd-usb-audio index=-2
```

⁷⁶ "FrontPage — PD Community Site." [Online]. Available: <http://puredata.info/docs/raspberry-pi>. (Accessed: 26-Mar-2013)

string to

```
$>> options snd_bcm2835=-2
```

and creating a `.libao` in the home directory with

```
$>> driver=alsa
$>> dev=default
```

strings.



Figure 47 Common USB ADC

Electret Microphone

This is a critical point, because it is very complicated to find a microphone that resists weather conditions and small enough to put in places like windows or breathers and not too expensive to be in a public place. We decide to use Peter Sinclair's suggestion for the Locus Sonus Project with a DIY microphone (Figure 48), that only needs 5v power through 2.20 kohm resistor (perfect for the USB connections) using an electret microphone⁷⁷.

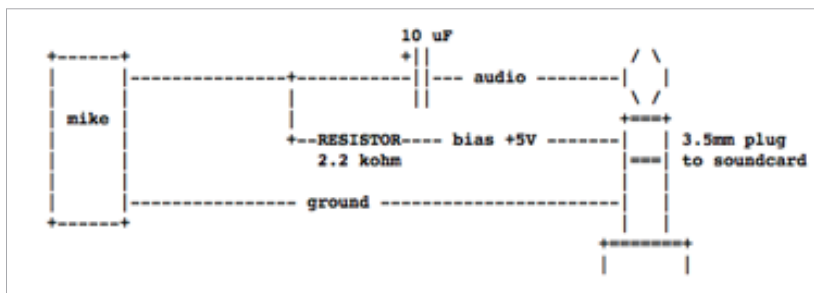


Figure 48 The Locus Mic DIY circuit

⁷⁷ "[http://locusonus.org/-Locustream LocusMic.](http://locusonus.org/-Locustream+LocusMic)" [Online]. Available: [http://locusonus.org/w/index.php?page=Locusstream+LocusMic.](http://locusonus.org/w/index.php?page=Locusstream+LocusMic) (Accessed: 26-Mar-2013).

6.3.2 Software Architecture Description

6.3.2.1 Sending and Storing Data

When sending and storing data online, URB relies on Python⁷⁸ and MySQL⁷⁹ to perform the tasks. The Python module works as an outside agent, responsible for building a query out of a float package put together by Pure Data (Pd)⁸⁰, and sending it to a MySQL database. This second component introduces a concurrent programming paradigm⁸¹ into URB's software architecture, as Python and Pd are seemingly working simultaneously through unidirectional message passing communication, via [shell] object. The presence of a second programming language on the client side of the system is deeply connected to the aesthetic and functional aspirations of the project. While it is advisable to keep a clean architecture and, therefore, avoid the presence of additional languages, the presented solutions for a Pd based project led to the decision of using a second language as a means of keeping the project intentions intact facing technical distortion.

As a programming environment focused on media and artistic production, Pure Data relies on community developed externals and libraries in order to perform SQL⁸² connections. At the moment, communication between Pd and SQLite⁸³ or PostgreSQL⁸⁴ databases are ensured by some externals⁸⁵, which is still a far from optimal set of solutions when, like in URB, as we will explain, using MySQL as a relational database management system is a binding need.

Although PostgreSQL presents itself as the most advanced open-source database system available⁸⁶, its usage implies the necessity of a dedicated server⁸⁷; a service that exceeds the dimensions of an

⁷⁸ Python is an open-source high-level programming language. <http://www.python.org>

⁷⁹ MySQL (MyStructured Query Language) is an open-source relational database management system. <http://www.mysql.com>

⁸⁰ Pure Data (Pd) is an open-source visual programming language for creating interactive computer music and multimedia works. <http://puredata.info>

⁸¹ A concurrent application will have two or more threads in progress at some time. This can mean that the application has two threads that are being swapped in and out by the operating system on a single core processor. These threads will be "in progress"—each in the midst of its execution—at the same time. (Breshears, 2009)

⁸² SQL (Structured Query Language) is a special-purpose programming language designed for managing data held in a relational database management system.

⁸³ SQLite is a relational database management system contained in a C programming library. <http://www.sqlite.org>

⁸⁴ PostgreSQL is an open-source object-relational database management system. <http://www.postgresql.org>

⁸⁵ Listed on Pd's official website are two different collections of externals whose purpose is to provide connection to a variety of relational databases. SQL library has no external to connect to a MySQL database and psql is reserved to PostgreSQL. "psql — PD Community Site. [Online]. Available: <http://puredata.info/downloads/psql/?searchterm=sql>. (Accessed: 02-Apr-2013).

⁸⁶ PostgreSQL is the hammer of the database world (...) It has plug-ins for natural-language parsing, multidimensional indexing, geographic queries, custom datatypes, and much more. It has sophisticated transaction handling, has built-in stored procedures for a dozen languages, and runs on a variety of platforms. (Redmond & Wilson, 2012)

⁸⁷ Right now, URB is being hosted at a Hostgator's shared server. According to Hostgator's services PostgreSQL is only available for Dedicated and VPS servers upon request.

<https://support.hostgator.com/articles/specialized-help/postgresql>

embryonic project like URB. On the other hand, SQLite lacks the user and permissions management needed⁸⁸ to build a much-needed community around this project. As was underlined before, URB's aesthetic agenda comprises easy access to the database in order to progressively build a clear picture of the city's soundscape and promote consistent usage of that material within the composition scope. Therefore, between PostgreSQL's over complexity and SQLite's deficiency on social tools, MySQL turns out to be the fittest solution to URB's data storage necessities, being a system that guarantees the possibility of social management with a simple shared server hosting service. Also, MySQL is quite a popular database system, which in the long term implies a much more rapid and responsive community, and a rather extensive collection of web articles and forum threads, both of which are positive attributes for a development tool.

With MySQL laid down as a vital option for the project, Pure Data's insufficiencies towards this database system needed to be overcome without any available externals and with C's development time being a drawback to the challenge of writing some new ones, the usage of additional languages became a viable hypothesis. Within Max, connecting to a MySQL database is a process that needs the support of Java. Queries are sent through Nick Rothwell's MySQL Java class⁸⁹ loaded into the [mxj] object; an approach easily ported to Pd through its [pdj] object, whose application programming interface (API) is based on the [mxj] implementation⁹⁰, making classes transferable between the two environments. So within Max⁹¹, Java⁹² works as an interpreted language just like his host, using Java Virtual Machine (JVM)⁹³ as an interpreter for the loaded code⁹⁴. Every time a message passes through the [pdj] inlet an access to the JVM is taking place, which can turn out to be minor step back in terms of performance, even though in this specific case, the message being conveyed is a list containing all the needed values.

In addition, and most importantly, by using these objects, the connection time needed for the code to access the on-line database with its query is being imported into the patch. So, this means that Pd would be responsible for handling both analysis and connection, the second being an obstacle to the first. Although this freezing time represents no significant disadvantage for a patch with a sampling

⁸⁸ An SQLite database has no authentication or authorisation data. Instead, SQLite depends on file system permissions to control access to the raw database file. This essentially limits access to one of three states: complete read/write access, read-only access, or no access at all. Write access is absolute, and allows both data modification and the ability to alter the structure of the database itself. (Kreibich, 2010)

⁸⁹ net.loadbang.sql.mxj.MySQL http://www.maxobjects.com/?v=objects&id_obj=3571&PHPSESSID=09ef5816e5d955699b350dedd401d647 (Accessed: 02-Apr-2013)

⁹⁰ PDJ enables you to write java code to interact with pure-data objects. The API is totally based on Cycling74 Max/MSP 'mxj' object implementation. This will enable java mxj objects to run on pure-data with pdj. pdj — PD Community Site. [Online]. Available: <http://puredata.info/downloads/pdj>. (Accessed: 02-Apr-2013).

⁹¹ Max is a visual programming language for music and multimedia. <http://cycling74.com/products/max/>

⁹² Java is a concurrent, class-based, object-oriented computer programming language. <http://www.java.com>

⁹³ Java Virtual Machine (JVM) is a process virtual machine that executes Java bytecode.

⁹⁴ The class files that live in the classes folder are what are known as byte code files. Unlike C externals, which are compiled into platform-specific machine code, Java byte code can be executed on any system that will run the JVM. Max6/java-doc/tutorial (Accessed: 02-Apr-2013)

rate of 5 seconds, the same cannot be said about a patch with a dynamic sampling rate, responsive to significant audio events captured at the input.

With C⁹⁵ representing an unnecessary amount of time in development and Java a blockage within the patch, Python revealed itself as a reasonable solution. Python is a high-level easy to learn multi-purpose language that is historically known for its harmonious cooperation with Linux and MySQL, a fact that in part led to the formation of the LAMP⁹⁶ software bundle⁹⁷. One can argue that Java's inclusion in the system through the [pdj] object is not mandatory. Open Sound Control (OSC)⁹⁸ could easily serve the purpose without damaging the performance of the patch. However, when developing for Raspberry Pi, Python is not only officially the primary programming language for the hardware⁹⁹, but also the interpreter and packages are available by default on both Debian¹⁰⁰ and Gentoo¹⁰¹ distributions (Gift & Jones, 2008). The readiness of Python when compared to the strict hardware and software specifications to make Java to compile builds a scenario where Python stands out as a much more robust and pragmatic solution than Java. (Downey, 2012)

Python's easy and flexible syntax allied to a stable MySQL library, MySQLdb¹⁰², result in a fast implementation of a straight-forward yet effective script to send queries to a MySQL database that is easily accessible through the shell thanks to the language's script mode. Assuming that URB's python script is in the /home/pi directory, the following command sends the appended list of 12 floats, one for each audio feature, to the MySQL database.

```
$>> python home/pi/urbsql.py 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

When run from Pd, the command can be constructed with a combination of [pack], [list] and [prepend] objects resulting on a string that is ready to be passed through the [shell] object (Figure 49).

⁹⁵ C is a general-purpose programming language.

⁹⁶ LAMP is an acronym that refers to a solution stack of software (Linux, Apache, MySQL and P (one of several scripting languages: Perl, PHP or Python)) used to run dynamic Web sites.

⁹⁷ MySQL is the dominant open source database management system: it is being used increasingly to build very significant applications based on the LAMP (Linux-Apache-MySQL-PHP/Perl/Python)(...). (Harrison & Feuerstein, 2009)

⁹⁸ OSC is a protocol for communication developed at CNMAT, for messaging among computers, sound synthesizers, and other multimedia devices optimized for modern networking technology. (<http://opensoundcontrol.org>)

⁹⁹ Does it have an official programming language? By default, we will be supporting Python as the educational language. Any language that will compile for ARMv6 can be used with the Raspberry Pi, though; so you are not limited to using Python. FAQs | Raspberry Pi." [Online]. Available: <http://www.raspberrypi.org/faqs>. (Accessed: 26-Mar-2013).

¹⁰⁰ Debian is a free operating system (OS) for your computer. <http://www.debian.org>

¹⁰¹ Gentoo is a free operating system based on either Linux or FreeBSD. www.gentoo.org

¹⁰² MySQLdb is a thread-compatible interface to the popular MySQL database server that provides the Python database API. <http://mysql-python.sourceforge.net/MySQLdb.html>.

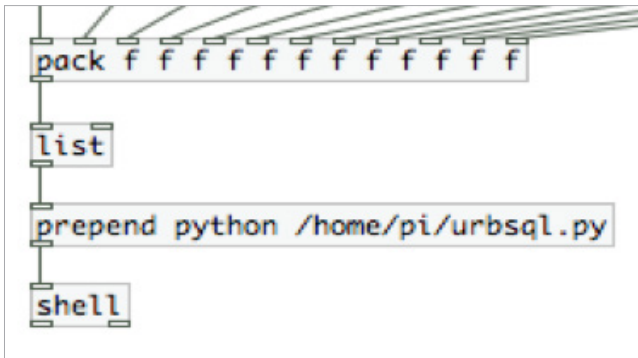


Figure 49 Construction of the shell command on a Pd patch.

6.3.2.2 The Database

At the moment, since URB is still in a prototype phase, the amount of data being produced and stored is minimal, if we compare to years of capture and analysis, and as such, database management is yet to become a challenge. It is well established for now that each location, each sound collection point will have its own table on the database, being that each table will take the name of its actual urban location (Figure 50).

The structure of each table is rather simple. Thirteen columns, one for each audio feature plus a first row that is using Unix Timestamp¹⁰³ as a means of identification and time localisation of the event described in the row. The continuous nature of the timestamp provides not only a stable sequence to order entries but also encloses meaningful information in itself by tagging the exact moment of the event and allowing further readings by crossing data from other sources. With the exception of the first column that takes integers with a display width of 11, all the other columns store varchar data width a display width of 255.

#	Coluna	Tipo	Agrupamento (Collation)	Atributos	Nulo	Omissão	Extra
1	id	int(11)			Não	None	AUTO_INCREMENT
2	pitch	varchar(255)	utf8_unicode_ci		Não	None	
3	amp	varchar(255)	utf8_unicode_ci		Não	None	
4	brightness	varchar(255)	utf8_unicode_ci		Não	None	
5	centroid	varchar(255)	utf8_unicode_ci		Não	None	
6	flatness	varchar(255)	utf8_unicode_ci		Não	None	
7	flux	varchar(255)	utf8_unicode_ci		Não	None	
8	kurtosis	varchar(255)	utf8_unicode_ci		Não	None	
9	rolloff	varchar(255)	utf8_unicode_ci		Não	None	
10	skewness	varchar(255)	utf8_unicode_ci		Não	None	
11	spread	varchar(255)	utf8_unicode_ci		Não	None	
12	zerocrossing	varchar(255)	utf8_unicode_ci		Não	None	
13	irregularity	varchar(255)	utf8_unicode_ci		Não	None	

Figure 50 Structure of a generic URB MySQL table

¹⁰³ Unix Timestamp is a way to track time defined as the number of seconds that have elapsed since 00:00:00 Coordinated Universal Time (UTC), Thursday, 1 January 1970.

Along with URB's database, a series of data visualisation and retrieval tools were designed in order to keep the dialogue sustainable even for the non-technical user. It is of the utmost importance that URB's data remains relevant and useable for the musician, composer or citizen without computational expertise; furthermore, all records are intended to be cleared of any composition methodology. The handling of URB's data does not mean to be programmatically defined in any way.

Already implemented are two different PHP¹⁰⁴ scripts that play a small part in what is expected to be a stable and refined project of data visualisation and retrieval. For now, these two scripts are responsible for the following outputs:

- Displaying the data of a specific table as an HTML¹⁰⁵ table. Regarded as a production tool, this allows monitoring the data flux without needing to log in to the host control panel.
- Export the data of a specific table as a .csv file (comma-separated values). Due to security constraints, direct access to the contents of a MySQL database is not often possible. This is the case with Javascript¹⁰⁶ (JS) and other JS based languages and frameworks like ProcessingJS¹⁰⁷. The way to avoid this technical predicament is to build a server side script that queries the database and exports the result as text file. URB's actual script exports all the data on a database; each call to the PHP script downloads the .csv file with the most recent set of data, making it accessible through Javascript.

Software architectural foundations have been set in a way that the gathering and distributing functions of the system work fluently and in a robust way, keeping options open. The main intention is to keep URB as an inviting platform for the users of the so-called creative programming frameworks such as Max, Pure Data, Processing, ProcessingJS, openFrameworks, Cinder, Nodebox, Shoebot, among others (Fry, 2008). With the already implemented code, URB has reached a maturity state that guarantees a fast and thorough development and evolution of the project into a ready-to-use tool and sharp investigation document.

¹⁰⁴ PHP general-purpose scripting language that is especially suited to web development. It is also used as a general-purpose programming language. <http://www.php.net>

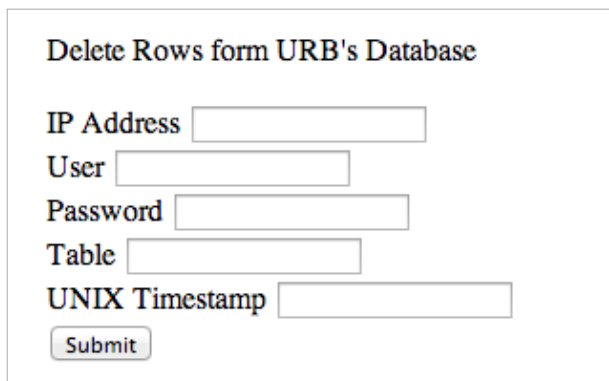
¹⁰⁵ HTML (HyperText Markup Language) is the main language used to creating web pages and other information that can be displayed in a web browser.

¹⁰⁶ JavaScript (JS) is a dynamic computer programming language commonly used as part of web browsers allowing client-side scripts to interact with the user.

¹⁰⁷ ProcessingJS is a partner project of the popular Processing visual programming language, designed for the web. It allows web browsers to display animations, visual applications, games and other graphical rich content without the need of any plug-ins.

6.3.2.3 Tools for Database Management

A few months after the system was working, we realised that it would not be practical to go to the database and delete lines manually every time that an error occurs. These errors arose primarily as a result of the installation and tuning process of the listening points, of the microphone malfunction or, as unfortunately happened, the theft of part of the hardware. To make this process simpler, and with the goal of a possible proliferation of listening points in the future, two simple python scripts were developed. This scripts works in a normal web browser and it is accessed through a normal web address, it allows any user, with access to all the information (database IP address and password) to delete any line of information (Figure 51) indicating the Unix timestamp or an entire section between two time points (Figure 52).



Delete Rows form URB's Database

IP Address

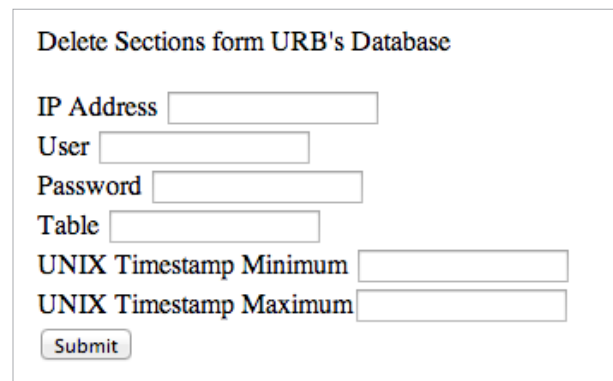
User

Password

Table

UNIX Timestamp

Figure 51 Web interface to delete one row of information



Delete Sections form URB's Database

IP Address

User

Password

Table

UNIX Timestamp Minimum

UNIX Timestamp Maximum

Figure 52 Web interface to delete a section of rows of information

6.3.2.4 Sound Analysis and information for the Data base

All the sound analysis is made on the Pure Data patch. The reason for choosing this open-source visual programming language has to do with several aspects: its tradition and capability for music/ technological projects, its open-source character, being associated to a strong and active community of artists and developers, having a strong development dedicated to hardware in use (Raspberry Pi), and already has tools and history of its use in art projects of a similar character.

The first part of the patch is about the audio input. It was inspired and based on the open-source software used by the LocustreamBox of the project Locustream Sound Map, described in the subchapter 3.1.10 - Locustream Sound Map & Locustreambox , with years of activity. Its purpose is adjusting the level (Figure 53), and equalising the sound in case you have some problems with noise, like from a vent or electricity (Figure 54).

2. Amplitude - the maximum extent of a vibration or oscillation, measured from the position of equilibrium.

(Framework of values: -0.000 – 1.0. In URB normally from 0.01 to 0.07)

To obtain it we use another native object [avg~] that computes the mean amplitude of its input signal since it last received a bang. The mean amplitude is the sum of the absolute values of the input divided by the number of samples received¹¹⁰.

The values presented are not decibels (dB). The purpose is not to represent the sound pressure level (SPL) accurately. For that purpose the methodology and hardware that we are proposing is not the most effective. Apart from the field of pressure mapping, most of the major cities, like Porto, already have very precise studies or effective systems. For example the research projects *Ruído na cidade do Porto - A evolução em duas décadas* (Noise in Porto - The evolution in two decades) (Carvalho and Jesus, 2011) or *O Som e o Ruído nos Jardins Urbanos do Porto* (The Sound and Noise in Porto Urban Gardens) (Dias, 2012) are only two very good examples of the study of sound pressures from the Acoustic field point of view. Adding to the academic practices, the Porto City Council has a Noise Lab to monitor and consecutively fulfil legal obligations under the General Regulation of Noise since 2011¹¹¹.

As such we believe that we do not have any experience or knowledge to add to this specific area. This feature is mainly a relative information to help understand the temporal evolution and comparison between listening points, as the hardware is the same.

The other 10 sound features are achieved by the *timbreID*¹¹² external Pd collection. *timbreID* is a Pd external collection developed by William Brent. It is composed of a group of objects for extracting timbral features, and a classification object that manages the resulting database of information. The objects are designed to be easy to use and adaptable for a number of purposes. (Brent, 2010) The option to use this collection, whose efficacy has already been proven in academic and artistic projects (Cordeiro, 2013; Brent, 2009, 2012; Bernardes, Gilberto, Guedes and Pennycook 2012; Bresson and Agon, 2007; Altavilla & Tanaka, 2012), and its open-source character have been a main guide to our project.

It implements a collection of low-level spectral audio descriptors: (Brent 2010; Zhang & Ras, 2007; Peeters, 2004).

3. Brightness - The ratio of the sum of magnitudes above a given boundary frequency to the sum of all magnitudes in a spectrum. Signals with a significant amount of high frequency content will

¹¹⁰ avg~ object's help patch (Accessed: 27-Mar-2013)

¹¹¹ <http://www.cm-porto.pt/gen.pl?p=stories&op=view&fokey=cmp.stories/19119> (Accessed: 13-Marc-2014)

¹¹² <http://williambrent.conflations.com/pages/research.html>.

have higher brightness. Noise will have much higher brightness than a sinusoid at 440 Hz.
(Framework of values: 0.000 – 1.0. In URB usually between 0.01 and 0.1)

4. Centroid - The centre of mass of a magnitude spectrum, and is a common low-level timbre feature. It is computed as the ratio of the sum of spectral magnitude weighted by frequency to the sum of spectral magnitude. Therefore, it reports the frequency associated with spectral centre of mass. Two perfect spikes in the spectrum at 400 Hz and 500 Hz produce a centroid near 450 Hz.
(Framework of values: 0Hz – 20kHz. In URB usually between 200Hz to 600 Hz)

5. Flatness - The ratio of the geometric mean of magnitude spectrum to the arithmetic mean of magnitude spectrum. A very noisy spectrum without clear shape (e.g. that of white noise) should have a high flatness value, where 1 is perfect flatness.
(Framework of values: 0.0 -1.0. In URB usually between 0.001 and 0.01)

6. Flux - Spectral flux is the sum of squared difference between two successive magnitude spectra. The range of values for flux depends on frame separation. With the default frame separation of a quarter window, the flux of a white noise generator is higher than that of a sinusoid.
(Framework of values: 0.0 -1.0. In URB usually between 0.14 and 0.26)

7. Kurtosis - Measures the peakedness of a spectrum. The kurtosis of a single sinusoid will be extremely high, while that of noise will be extremely low.
(Framework of values: 0 – 97000. In URB usually between 100 and 2500)

8. Roll Off - The frequency below which a certain amount of total spectral energy is concentrated. The concentration set is 0.85. The rolloff for the single 440 Hz sinusoid is actually 473.73 Hz when N=1024 and SR=44100.
(Framework of values: 0 Hz – 20kHz. In URB usually between 250Hz to 1000Hz)

9. Skewness - Measures the symmetry of a spectral envelope. Positive skew means most of the energy is in the low end, and the envelope tapers to 0 toward the higher frequencies. Negative skew is the opposite: most of the energy is at the high end, and the envelope tapers to 0 toward the low frequencies. Unfiltered white noise will have a skew value near 0.
(Framework of values: -20 – 20. In URB usually around 10)

10. Spread - A measure of the concentration of a spectrum's energy around its centroid. It is reported in units of Hz. A sinusoid will have a very low spread value because all of the energy in its spectrum is in one place. Noise will have a high spread.
(Framework of values: 70 – 6500. In URB usually between 550 and 1000)

11. Zero-Crossing - A simple way to measure a signal's noisiness is to count the number of times it crosses 0 in a given window. This information is also related to frequency. Zero crossing is

sometimes used as a crude timbre feature.

(Framework of values: 0–550. In URB usually between 1 and 10)

12. Irregularity - Spectral Irregularity is to inspect a spectrum from low to high and see how much each frequency bin compares to its immediate neighbours. For jagged spectra, irregularity will be high, and for smooth contoured spectra, it will be low. This measure is important for timbre perception (Caclin, McAdams, Smith and Winsberg, 2005). The irregularity xii. of a sawtooth wave (with a spiky spectrum) is much more than low-pass filtered noise.

(Framework of values: 0.20 – 0.65. In URB usually around 0.29)

The framework that is usually pointed out in the URB project was concluded by observing the project working from May 2013 to November 2014: it is only a guideline to what artists or observers can expect and not an established framework.

It is debatable if such complete timbral features are necessary or pertinent in the soundscape context. However, for the implementation of all the features presented in the *timberID* collection in any way adversely affects the system process. So even though at this time we do not see application for some elements, we believe that we can be surprised with people's creativity. As such this approach will increase the project's ability to respond to future demands or needs leaving the project scope flexible to ecological or artistic exploration and research.

Every five minutes the patch calculates the main value of each feature of that time and sends that value for the database (Figure 55). During our tests we realise that the five-minute window is a sustainable amount of time to provide a clear “image” of the urban soundscape in a larger scale of time. It is a manageable number of entries to the database and doable for its storage in a long-term situation. It is around 553MB for a century of information for each listening point. However this time lapse to make the average and to send to database can be changed easily. So for specific situations, or an individual user, this parameter can be changed and do a time zoom in or zoom out in their recorder.

This descriptors data is very powerful information. In recent years, the research about sound classification and genre identification is increasing exponentially. With the classification and similarity tools, URB can give detailed information about every 5 minutes of a soundscape, not only quantitative information but also especially qualitative information. Saying if the sound is more industrial or natural, speech or non-speech, noisy or pitched, and compare with other moments or with other soundscapes. However, the most important feature is that it is possible to compare the sound from different moments, with a very high degree of accuracy. It is going to be possible to understand the evolution of the sound during that day, month, year etc.

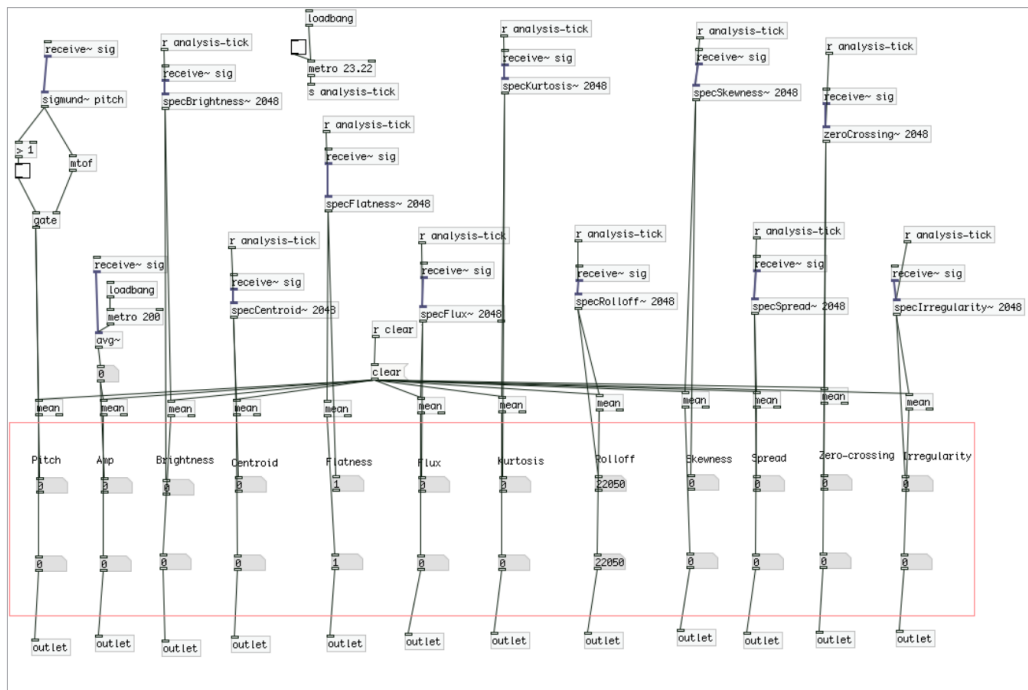


Figure 55 pd descriptors

Our goal is not only to develop an ecological or an observatory system. We are very convinced of the artistic potential. The classification tools are already used in concatenative sound synthesis (Schwarz, 2006; Bernardes, Gilberto, Guedes and Pennycook, 2012) for example, and with URB this process can be controlled by a soundscape. Eco-Composition and Eco-Structuralism, as we describe in subchapter 2.7, already uses sound and ecological structures to apply in music creation, and with URB you have a repository of eco structures from soundscapes that you can use for music or visual creation for example.

The first version of the software was able to stream the soundscape in real time, like the Locustream Sound Map project, and aimed to integrate that project in the future. Although this approach was not the main purpose of our research, the effort in implementing this aspect was so accessible and low that it seemed to us like a good opportunity for another way to contribute to the Soundscape community. That process with the French research group was even started. However, we had to give up from this feature. During the first tests in the public spaces we realised that this was a serious problem of personal privacy. The microphones were near home windows or in coffee shops terraces. Conversations whose interlocutors thought they were having in private were quite perceptible, and quickly matters that should not leave the private realm emerged. In urban areas of high density, it is quite hard to not capture private contexts in a non-stop system. Although the issue of privacy in the context of the study and capturing of soundscapes is a subject of great interest and relevance, we conclude that it was significantly out of our scope. As such we removed this component from our project.

The URB-box Pd patch score can be found in Appendix E

6.3.3 Listening Points Implementation

After the hardware development we proceeded to the listening points implementation in the public space. In this phase of the project, we decided to set four URB-boxes/listening points through the centre of the city. Due to this testing phase and the unpredictable number of times it would be intervened, the URB-boxes were implemented in places that were kindly ceded by individuals or cultural institutions that ensured easy access.

The requirements were: access to the relevant public area, for example the a back alley does not have interest in this phase of the project, and access to internet via ethernet cable and electricity.

The type of internet connection was an issue that we spent some time studying and discussing. Cable is not the most practical solution, but the wireless possibility presented some problems. The most obvious was the cost. It would increase the price of each URB-box that presented a possible obstacle to the public dissemination. The others problems were in the technical field. No solution on the market at the time showed enough fidelity or robustness to a system which is supposed to be in operation 24 hours a day for extremely long periods of time. Adding to that issue, the wireless adaptors presented some incompatibilities with the USB analogue to digital adapter making the use of a powered USB hub essential. Nevertheless if in the future the market provides more robust solutions or if any user chooses the wireless solution, it will not affect our developed software or hardware and there will be no necessary adjustment. Recent news has shown great news for alternatives in the near future for electrical power, such as Power over Ethernet (PoE) possibilities¹¹³ where the Raspberry Pi is remotely powered by the ethernet cable, or even more exciting possibilities, like solar power. In recent months the Do It Yourself (DIY) community has presented numerous attempts, many successful, to feed the Raspberry Pi using solar energy¹¹⁴. At the time those are still unstable solutions that require large resources, which would not be sustainable for a project with the characteristics of ours, but we believe they will significantly improve in the near future.

Four listening points were installed: (Figure 56)

1. Sá da Bandeira Street / Bolhão Market
2. Oliveira Monteiro Street / Geographic center
3. Mouzinho de Albuquerque Square / Casa da Música
4. Prelada Street / Sonoscopia Cultural Association

¹¹³ e.g. <http://www.xtronix.co.uk/raspberry-pi-poe.htm> (Accessed: 19-Mar-2014)

¹¹⁴ e.g. <http://www.instructables.com/id/Solar-Powered-Raspberry-Pi/> (Accessed: 19-Mar-2014)



Figure 56 Listening points distribution in Porto

The first URB-box was installed in a window of the centre of the city, on Sá da Bandeira Street ($41^{\circ}08'59.4''\text{N}$ $8^{\circ}36'26.8''\text{W}^{115}$), pointed to the Bolhão Market (Figure 57), the most important and traditional market in the region. The data collection began at 06 Jun 2013 22:06:59 GMT (1370556419 Unix Time).



Figure 57 First listening point on Sá da Bandeira Street

¹¹⁵ Measurements made via Google Maps©

The second URB-box was installed in a balcony facing the street on Oliveira Monteiro Street (41°09'25.9"N 8°37'14.6"W) (Figure 58). This area is near the geographic centre of the city, however it has a very different public function and ambience compared to the first listening point. It is more a residential area and an important path to enter or leave the city centre with very intense traffic. The data collection began 02 Jul 2013 16:56:47 GMT (1372784207 Unix Time).



Figure 58 Second listening point on Oliveira Monteiro Street

The next two listening points have a different approach. They are both in artistic institutions. The third is in the most important concert hall of the city, Casa da Música¹¹⁶, with a global artistic relevance at the Mouzinho de Albuquerque square (41°09'31.3"N 8°37'50.9"W). This URB-box is pointed to a public place with a very different character from the rest of the others. Is in a small square around 50 metres away from the street. The place is used a lot by skaters and families during the weekend and during the summer a coffee shop is installed on the terrace with ambient music and a small stage with concerts during the night. The building is visited by thousands of tourists during the year. So the sound ambience has a very different character. (Figure 59) The data collection began 09 Aug 2013 15:04:46 GMT (1376060686 Unix Time).

¹¹⁶ www.casadamusica.com

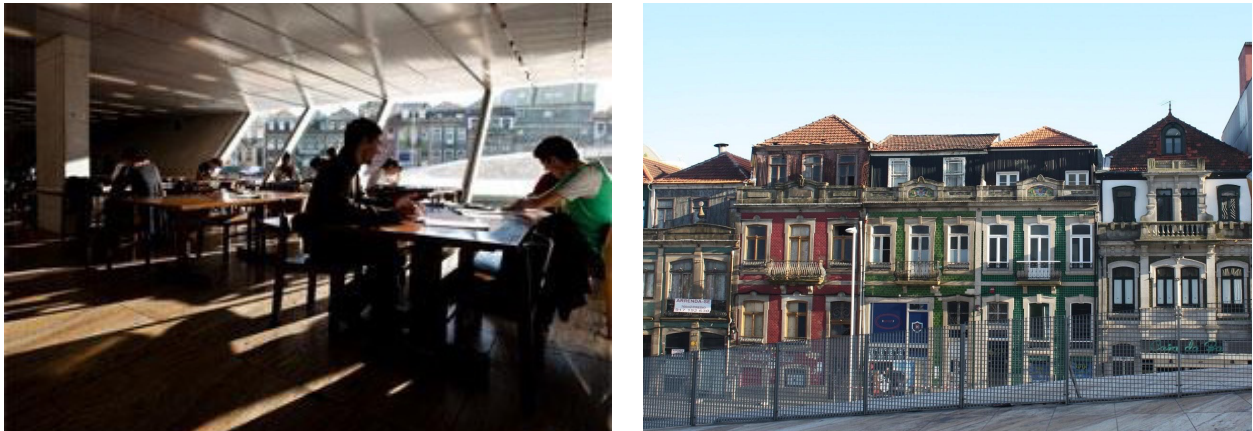


Figure 59 Third listening point at Casa da Música.

The last listening point was installed in the headquarters of the cultural association Sonoscopia¹¹⁷ on Prelada Street ($41^{\circ}10'01.6''\text{N}$ $8^{\circ}37'36.3''\text{W}$). This association is a sonic art promoter with a strong connection to soundscapes concerts, installations and research projects. Besides promoting concerts and artistic residencies, it hosts the Porto Sonoro sound archive and sound map project, described in detail in subchapter 3.1.8 - Porto Sonoro. The reason of the choice of this specific place was not about the public area itself but because of the interest that the artists involved in the association to work artistically with the soundscape that surrounds them. The URB-box was installed in a small balcony pointed to the street (Figura 60). This area is still inside the city of Porto but apart of the city centre with different resident and economic synergies. It is a place with small street businesses with a community of old residents. Data collection began 22 Oct 2013 21:39:04 GMT (1382477944 Unix Time).



Figure 60 Fourth listening point at Sonoscopia cultural association.

¹¹⁷ www.sonoscopia.pt

This phase of implementation showed no problems, proving the robustness of the hardware and software so far. The first two listening points did not have any problem and did not require any intervention since the first day of installation. The only apparent problems were in the second and third listening points in the microphones with minor problems due to incorrect assembly. Trying for a year, with a harsh winter, of experience with part of the hardware placed outside we believe that this is a sustainable solution for a project with these characteristics. This view is also supported from the feedback of various Raspberry Pi users in projects with non-stop operations. The general feedback is that the hardware worked without problems for years with only a few reports of overheating in the power connection.

6.4 Database Consultation Software

The most direct way to consult the URB databases (Figure 61) is directly through the browser or downloading a text format file (Figure 62), both available on the project website.

Unix Time	Pitch	Amplitude	Brightness	Centroid	Flatness	Flux	Kurtosis	Roll Off	Skewness	Spread	Zero-Crossing	Irregularity
1370556419	109.757	0.0230705	0.0774719	334.498	0.00574565	0.183035	275.869	668.138	9.63276	742.53	4.32019	0.29222
1370556892	106.821	0.0235625	0.0746645	330.144	0.00567318	0.188636	251.383	661.406	9.77766	735.538	4.3404	0.290614
1370557375	96.075	0.0254423	0.0692845	309.863	0.00554835	0.212594	233.789	609.22	10.3407	709.727	4.62198	0.28068
1370557858	95.7336	0.0251187	0.067574	304.166	0.00546553	0.218969	257.617	583.75	10.5781	700.697	5.20209	0.271719
1370558334	92.6998	0.025959	0.0701154	300.731	0.00543869	0.218917	300.151	569.94	10.4604	710.616	4.69342	0.276671
1370558814	101.684	0.0245767	0.0702824	312.777	0.00541563	0.217859	238.15	601.41	10.2651	710.57	5.2308	0.272542
1370559292	99.9599	0.0247831	0.065984	299.922	0.0054095	0.212733	307.066	563.22	10.5641	710.762	4.83243	0.274633
1370559768	101.228	0.0241194	0.0663833	302.855	0.005405	0.214671	288.047	571.79	10.6137	709.484	5.12988	0.272559
1370560289	105.062	0.0229762	0.0650986	291.033	0.00542651	0.20466	384.608	529.66	10.7827	722.106	4.43204	0.276683
1370560732	100.351	0.0247575	0.0678746	301.52	0.00542452	0.212269	311.774	565.314	10.5267	713.41	4.89496	0.276035
1370561212	102.494	0.0270117	0.0777121	334.236	0.00539526	0.230134	173.876	661.583	9.57652	711.015	5.80232	0.271362
1370561690	106.732	0.0232245	0.0626706	283.402	0.00541038	0.203211	480.283	496.047	11.0989	717.522	4.25534	0.280196
1370562176	103.245	0.0255489	0.0683531	301.92	0.00540333	0.2173	313.245	556.71	10.5327	711.115	4.97531	0.270972
1370562647	104.74	0.0272632	0.0740825	324.18	0.00538554	0.223146	287.798	597.883	9.88203	710.659	5.76339	0.271917
1370563134	101.046	0.0248601	0.0647105	288.732	0.00538828	0.208457	395.404	521	10.8943	711.88	4.5281	0.278741
1370563611	99.9276	0.0233005	0.0581831	254.747	0.00541794	0.194346	631.008	406.321	11.555	727.822	3.00209	0.285195
1370564092	106.868	0.0216325	0.058615	251.022	0.00545185	0.189011	693.157	388.384	11.651	736.936	2.58119	0.28431
1370564570	103.335	0.0222572	0.0580647	256.351	0.00547327	0.193145	665.472	409.601	11.605	728.103	3.07546	0.280718
1370565055	106.541	0.0226491	0.0598759	266.463	0.00548327	0.197082	570.965	443.051	11.4564	719.366	3.56347	0.280693
1370565533	104.61	0.0217511	0.0579242	241.624	0.00551357	0.183585	846.57	344.988	11.7728	741.691	2.17099	0.287143
1370566010	114.148	0.0256323	0.0536659	238.848	0.00552615	0.183449	834.209	331.228	12.1452	719.651	2.62175	0.291521
1370566483	104.726	0.0215793	0.0573564	238.789	0.00555243	0.179413	987.678	319.895	11.8444	743.868	2.03684	0.288762
1370566955	103.118	0.0222712	0.0583311	250.151	0.00556959	0.188059	746.651	379.518	11.6691	734.094	2.62059	0.286435
1370567437	105.895	0.022329	0.0598116	247.865	0.00558839	0.184185	825.036	354.061	11.5935	740.756	2.4565	0.287587
1370567912	109.865	0.021557	0.0674458	261.842	0.00560406	0.184712	726.054	393.231	11.1813	747.406	2.51409	0.285776
1370568388	107.387	0.0215575	0.0603962	241.749	0.00562625	0.176598	990.419	317.448	11.6727	752.519	1.83086	0.291538
1370568862	102.01	0.0223251	0.0493187	206.674	0.00563008	0.177822	1005.61	264.118	13.9438	705.392	1.64211	0.290914
1370569346	104.633	0.0210215	0.0309792	164.76	0.00562144	0.168911	1447.87	215.779	17.1563	665.029	1.28328	0.292301
1370569824	103.988	0.0214578	0.0343849	178.153	0.00561299	0.175715	1377.7	247.192	16.5389	667.292	1.76347	0.288308
1370570305	103.707	0.0207945	0.0284877	151.089	0.00560993	0.166287	1657.8	171.142	17.5488	668.572	0.824522	0.291358
1370570787	103	0.0214228	0.0260955	145.491	0.00560351	0.168152	1748.42	167.612	17.9583	661.127	0.982276	0.292032
1370571267	101.64	0.0217595	0.0344759	180.169	0.00559545	0.180005	1185.15	259.075	16.4777	663.68	1.96594	0.289338
1370571744	105.777	0.0210024	0.0279637	154.987	0.00559024	0.169345	1565.15	189.842	17.6019	662.612	1.2572	0.289256
1370572221	102.133	0.0217145	0.0286833	158.765	0.00558366	0.173714	1385.41	198.689	17.4272	658.61	1.32872	0.291881
1370572709	104.011	0.0207841	0.0293704	154.278	0.00558048	0.166023	1739.02	187.709	17.5229	668.646	0.966796	0.293553
1370573188	102.793	0.020956	0.0277296	151.971	0.00557676	0.167534	1685.52	185.706	17.6885	665.062	1.01548	0.293603

Figure 61 Database web browse consultation

```

id;pitch;amp;brightness;centroid;flatness;flux;kurtosis;rolloff;skewness;spread;zerocrossing;irregularity;
1370556419; 109.757; 0.0230705; 0.0774719; 334.498; 0.00574565; 0.183035; 275.869; 668.138; 9.63276; 742.53; 4.32019; 0.29222;
1370556892; 106.821; 0.0235625; 0.0746645; 330.144; 0.00567318; 0.188636; 251.383; 661.406; 9.77766; 735.538; 4.3404; 0.290614;
1370557375; 96.075; 0.0254423; 0.0692845; 309.863; 0.00554835; 0.212594; 233.789; 609.22; 10.3407; 709.727; 4.62198; 0.28068;
1370557858; 95.7336; 0.0251187; 0.067574; 304.166; 0.00546553; 0.216969; 257.617; 583.75; 10.5781; 700.697; 5.20209; 0.271719;
1370558334; 92.6998; 0.025959; 0.0701154; 300.731; 0.00543869; 0.218917; 300.151; 569.94; 10.4604; 710.616; 4.69342; 0.276671;
1370558814; 101.684; 0.0245767; 0.0702824; 312.777; 0.00541563; 0.217659; 238.15; 601.41; 10.2651; 710.57; 5.2308; 0.272542;
1370559292; 99.9599; 0.0247831; 0.065984; 299.922; 0.0054095; 0.212733; 307.066; 563.22; 10.5641; 710.762; 4.83243; 0.274633;
1370559768; 101.228; 0.0241194; 0.0663833; 302.855; 0.005405; 0.214671; 288.847; 571.79; 10.6137; 709.484; 5.12988; 0.272559;
1370560269; 105.062; 0.0229762; 0.0650986; 291.033; 0.00542651; 0.20466; 384.608; 529.66; 10.7827; 722.106; 4.43204; 0.276683;
1370560732; 100.351; 0.0247575; 0.0678746; 301.52; 0.00542452; 0.212269; 311.774; 565.314; 10.5267; 713.41; 4.89496; 0.276935;
1370561212; 102.494; 0.0270117; 0.0777121; 334.236; 0.00539526; 0.230134; 173.876; 661.583; 9.57652; 711.015; 5.80232; 0.271362;
1370561690; 106.732; 0.0232245; 0.0626706; 283.402; 0.00541038; 0.203211; 480.283; 496.047; 11.0989; 717.522; 4.25534; 0.280196;
1370562176; 103.245; 0.0255489; 0.0683531; 301.92; 0.00540333; 0.2173; 313.245; 556.71; 10.5327; 711.115; 4.97531; 0.270972;
1370562647; 104.74; 0.0272632; 0.0740825; 324.18; 0.00538554; 0.223146; 287.798; 597.883; 9.88203; 710.659; 5.76339; 0.271917;
1370563134; 101.046; 0.0248601; 0.0647105; 288.732; 0.00538828; 0.208457; 395.404; 521; 10.8943; 711.88; 4.5281; 0.278741;
1370563611; 99.9276; 0.0233005; 0.0581831; 254.747; 0.00541794; 0.194346; 631.008; 406.321; 11.555; 727.822; 3.00209; 0.285195;
1370564092; 106.868; 0.0216325; 0.058615; 251.022; 0.00545185; 0.189011; 693.157; 388.384; 11.651; 736.936; 2.58119; 0.28431;
1370564570; 103.335; 0.0222572; 0.0580647; 256.351; 0.00547327; 0.193145; 665.472; 409.601; 11.605; 728.103; 3.07546; 0.280718;
1370565055; 106.541; 0.0226491; 0.0598759; 266.463; 0.00548327; 0.197082; 570.965; 443.051; 11.4564; 719.366; 3.56347; 0.280693;
1370565533; 104.61; 0.0217511; 0.0579242; 241.624; 0.00551357; 0.183585; 846.57; 344.988; 11.7728; 741.691; 2.17099; 0.287143;
1370566010; 114.148; 0.0256323; 0.0536659; 238.848; 0.00552615; 0.183449; 834.209; 331.228; 12.1452; 719.651; 2.62175; 0.291521;
1370566483; 104.726; 0.0215793; 0.0573564; 238.789; 0.00555243; 0.179413; 987.678; 319.895; 11.8444; 743.868; 2.03684; 0.288762;
1370566955; 103.118; 0.0222712; 0.0583311; 250.151; 0.00556959; 0.188059; 746.651; 379.518; 11.6691; 734.094; 2.62059; 0.286435;
1370567437; 105.895; 0.022329; 0.0598116; 247.865; 0.00558839; 0.184185; 825.036; 354.061; 11.5935; 740.756; 2.4565; 0.287587;
1370567912; 109.865; 0.021575; 0.0674458; 261.842; 0.00560406; 0.184712; 726.054; 393.231; 11.1813; 747.406; 2.51409; 0.285776;
1370568388; 107.387; 0.0215557; 0.0603962; 241.749; 0.00562625; 0.176598; 990.419; 317.448; 11.5727; 752.519; 1.83096; 0.291538;
1370568862; 102.01; 0.0223251; 0.0493187; 206.674; 0.00563008; 0.177822; 1005.61; 264.118; 13.9438; 705.392; 1.64211; 0.290914;
1370569346; 104.633; 0.0219215; 0.0389792; 164.76; 0.00562144; 0.168911; 1447.87; 215.779; 17.1563; 665.029; 1.28328; 0.292301;
1370569824; 103.988; 0.0214578; 0.0343849; 178.153; 0.00561299; 0.175715; 1377.7; 247.192; 16.5389; 667.292; 1.76347; 0.288308;
1370570305; 103.707; 0.0227945; 0.0284877; 151.089; 0.00560993; 0.166287; 1657.8; 171.142; 17.5488; 668.572; 0.824522; 0.291358;
1370570787; 103; 0.0214228; 0.0260955; 145.491; 0.00560351; 0.168152; 1748.42; 167.612; 17.9583; 661.127; 0.982276; 0.292032;
1370571267; 101.64; 0.0217595; 0.0344759; 180.169; 0.00559545; 0.180005; 1185.15; 259.075; 16.4777; 663.68; 1.96594; 0.289338;
1370571744; 105.777; 0.0210024; 0.0279637; 154.987; 0.00559024; 0.169345; 1565.15; 189.842; 17.6019; 662.612; 1.2572; 0.289256;
1370572221; 102.133; 0.0217145; 0.0286833; 158.765; 0.00558366; 0.173714; 1385.41; 198.689; 17.4272; 658.61; 1.32872; 0.291881;
1370572709; 104.011; 0.0207841; 0.0293704; 154.278; 0.00558048; 0.166023; 1739.02; 187.709; 17.5229; 668.646; 0.966796; 0.293553;
1370573188; 102.793; 0.020956; 0.0277296; 151.971; 0.00557676; 0.167534; 1685.52; 185.706; 17.6885; 665.062; 1.01548; 0.293603;
1370573663; 102.248; 0.0217992; 0.0359773; 188.099; 0.00556932; 0.181768; 1138.51; 278.272; 16.2013; 663.697; 2.14481; 0.287803;
1370574139; 102.687; 0.0217322; 0.0341578; 177.064; 0.00556285; 0.175383; 1306.07; 241.562; 16.6048; 663.876; 1.76633; 0.289657;
1370574625; 101.843; 0.0229305; 0.0413032; 204.81; 0.0055532; 0.187029; 976.998; 330.034; 15.425; 663.51; 2.57125; 0.285198;
1370575112; 100.589; 0.0220822; 0.03443; 182.365; 0.00554586; 0.180457; 1123.34; 269.948; 16.4846; 659.957; 1.92159; 0.288908;
1370575587; 103.114; 0.0212912; 0.0301329; 158.89; 0.00554256; 0.168453; 1649.38; 201.165; 17.397; 665.142; 1.27701; 0.292305;
1370576063; 103.753; 0.0208409; 0.0293022; 166.113; 0.00554012; 0.17087; 1396.12; 219.335; 17.2025; 665.23; 1.42879; 0.292989;
1370576540; 101.919; 0.0213406; 0.0315278; 163.145; 0.00553733; 0.170857; 1526.88; 208.252; 17.2057; 666.089; 1.44799; 0.293508;
1370577018; 103.526; 0.0215189; 0.030873; 165.517; 0.00553; 0.174143; 1392.01; 218.309; 17.1376; 660.434; 1.55619; 0.288061;
1370577496; 103.3; 0.0217532; 0.0298654; 156.648; 0.00553047; 0.169745; 1552.96; 185.786; 17.304; 663.631; 1.16339; 0.29403;
1370577974; 102.327; 0.0218694; 0.0362531; 186.209; 0.00552626; 0.179972; 1185.33; 273.672; 16.2855; 665.517; 2.02206; 0.288155;
1370578455; 101.028; 0.0217741; 0.0348987; 182.386; 0.00552242; 0.178922; 1202.28; 262.355; 16.3928; 664.451; 1.93839; 0.289947;
1370578938; 103.386; 0.0217264; 0.0345733; 186.375; 0.00551879; 0.176385; 1002.53; 277.195; 16.2537; 665.679; 1.59172; 0.293222;
1370579412; 102.961; 0.021415; 0.0335546; 175.679; 0.00551716; 0.173619; 1318.92; 238.704; 16.5247; 668.765; 1.5599; 0.289688;
1370579891; 103.576; 0.0221955; 0.0369562; 182.405; 0.00551489; 0.173413; 1285.23; 249.068; 16.0974; 671.943; 1.67245; 0.290682;
1370580370; 104.289; 0.0222813; 0.0421613; 211.2; 0.00550943; 0.18539; 901.443; 344.141; 15.1917; 666.355; 2.68313; 0.284869;
1370580853; 103.888; 0.0216789; 0.0332155; 177.033; 0.00550782; 0.172556; 1262.42; 247.045; 16.4438; 667.529; 1.52872; 0.291302;
1370581345; 105.247; 0.0225763; 0.0429162; 210.532; 0.00550466; 0.182471; 1002.73; 321.418; 15.0188; 675.254; 2.538; 0.286227;
1370581827; 100.882; 0.0232756; 0.0415219; 205.786; 0.00550123; 0.185275; 911.323; 306.825; 15.0596; 670.637; 2.49582; 0.286888;
1370582306; 108.302; 0.0217139; 0.0441169; 195.785; 0.0055053; 0.172913; 1206.07; 262.952; 15.1112; 696.642; 1.76772; 0.293006;
1370582787; 109.327; 0.0227875; 0.0596547; 239.609; 0.00550934; 0.189792; 739.923; 386.521; 13.0264; 713.218; 2.68437; 0.286986;
1370583265; 104.589; 0.0233014; 0.0408031; 213.874; 0.00550985; 0.183985; 877.467; 315.458; 14.2215; 689.253; 2.31517; 0.28678;
1370583745; 104.375; 0.0249529; 0.060697; 260.654; 0.00550973; 0.200533; 474.82; 456.264; 12.1747; 704.001; 3.58073; 0.284006;
1370584227; 99.2743; 0.0251342; 0.0758704; 309.273; 0.00551189; 0.212246; 216.394; 614.377; 10.2455; 727.419; 4.62118; 0.281132;
1370584712; 112.298; 0.025382; 0.0675152; 298.553; 0.00550509; 0.214049; 200.031; 572.273; 11.1835; 691.208; 4.98669; 0.27296;
1370585193; 104.235; 0.0259986; 0.0742041; 306.697; 0.00549912; 0.221818; 193.728; 589.863; 10.7446; 699.123; 5.00464; 0.27475;
1370585663; 110.606; 0.0230209; 0.0622877; 262.283; 0.00550436; 0.197025; 459.64; 453.487; 11.8696; 721.115; 3.25062; 0.281981;
1370586141; 102.17; 0.0239979; 0.0541424; 235.799; 0.00550432; 0.193018; 594.784; 381.071; 13.2882; 693.712; 2.80077; 0.285456;
1370586677; 94.4102; 0.0288727; 0.0784934; 292.151; 0.00549644; 0.226253; 263.334; 548.8; 11.1092; 687.975; 4.59249; 0.286628;
1370587097; 103.98; 0.0248965; 0.0662691; 287.397; 0.00549063; 0.21448; 250.255; 553.707; 11.7779; 686.305; 4.57028; 0.277471;

```

Figure 62 Database text file

With these two ways to consult the databases, although all the information is accessible, it might not very useful or hard to transform to friendlier formats to use in artistic creation. It is very important for our purposes that the project be accessible to the most generic audience possible and not only the ones that have very specific technical knowledge to deal with this type of information. With the aim of bridging this aspect we developed a tool to facilitate the access and future uses and outputs for the databases.

This tool, named URB-app, was developed in Max¹¹⁸. The decision to use this tool was a difficult one. It is not freeware or open source. However, it is the most popular software of this kind used by artists, with a long history in the field and with a large and strong community connected to it, with a relatively simple approach compared to other programming languages of lower-levels. Due to this

¹¹⁸ Max is a visual programming language for music and multimedia. It is used by composers, performers, software designers, researchers, and artists for creating recordings, performances, and installations. <http://cycling74.com/products/max/> (Accessed: 25 March 2014)

wider audience combined with the fact that Max has a free runtime version as well as being possible to freely distribute a standalone version, we decided to proceed with this solution.

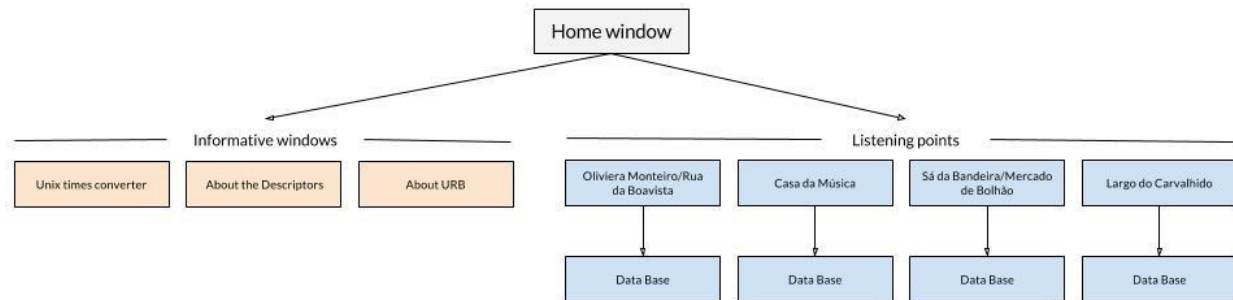


Figure 63 URB-app map

6.4.1 URB-app Description

In this subchapter we going to describe the structure, organization and and operation of the URB-app in detail. (Figure 63)

Home Window

The first software window (Figure 64) shows a general interface where the user can choose with which listening point they want to consult and interact. Additionally it has three smaller buttons for informative windows: Unix timestamp converter, About the Descriptors, About URB.

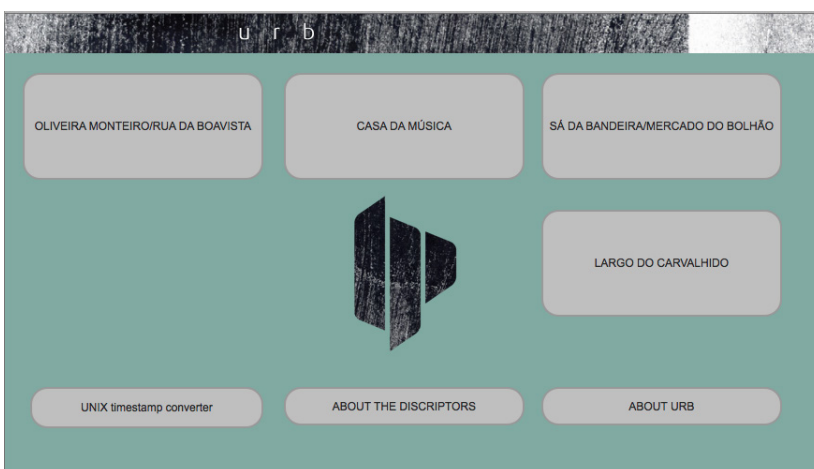


Figure 64 URB-app main window

Unix time converter

Is a simple helper that converts Unix time to the civil standard¹¹⁹ UTC+00:00¹²⁰ and vice versa (Figure 65)

The image shows a web-based time converter interface. At the top, there are six input fields labeled 'year', 'month', 'day', 'hour', 'min', and 'sec'. Below these, the values '2014', '2', '11', '19', '13', and '5' are entered. In the center, there is a single input field labeled 'UNIX TimeStamp' containing the value '1392145985'. At the bottom, there is another set of six input fields labeled 'year', 'month', 'day', 'hour', 'min', and 'sec', with the same values '2014', '2', '11', '19', '13', and '5' entered.

Figure 65 URB-app time converter

The algorithm applied to the conversion was:

```
def timestamp_to_gmt_civil(ts)
    s = ts%86400
    ts /= 86400
    h = s/3600
    m = s/60%60
    s = s%60
    x = (ts*4+102032)/146097+15
    b = ts+2442113+x-(x/4)
    c = (b*20-2442)/7305
    d = b-365*c-c/4
    e = d*1000/30601
    f = d-e*30-e*601/1000
    (e < 14 ? [c-4716,e-1,f,h,m,s] : [c-4715,e-13,f,h,m,s])
end
```

¹¹⁹ ISO 8601:2004 (International Organization for Standardization).

http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=40874 (Accessed: 25 March 2014)

¹²⁰ UTC (Coordinated Universal Time) is the time standard by which the world synchronises clocks and time.

```

def gmt_civil_to_timestamp(y, m, d, h, mi, s)
  if m <= 2; y -= 1; m += 12; end
  (365*y + y/4 - y/100 + y/400 + 3*(m+1)/5 + 30*m + d -
  719561) *
    86400 + 3600 * h + 60 * mi + s
end
t = Time.now.to_i
fail if t != gmt_civil_to_timestamp(*timestamp_to_gmt_civil(t))

```

The algorithmic solution above is part of the programming folklore¹²¹.

About the Descriptors

This is a simple window with detailed information about the sound descriptors used in the system (Figure 66), described in subchapter 6.3.2.4 - Sound Analysis and Information for the Database. The function is that the users have fast access about the meaning of each sound descriptor considered fundamental to understand and decode the database properly and therefore, if such is the purpose, to have artistic decisions.

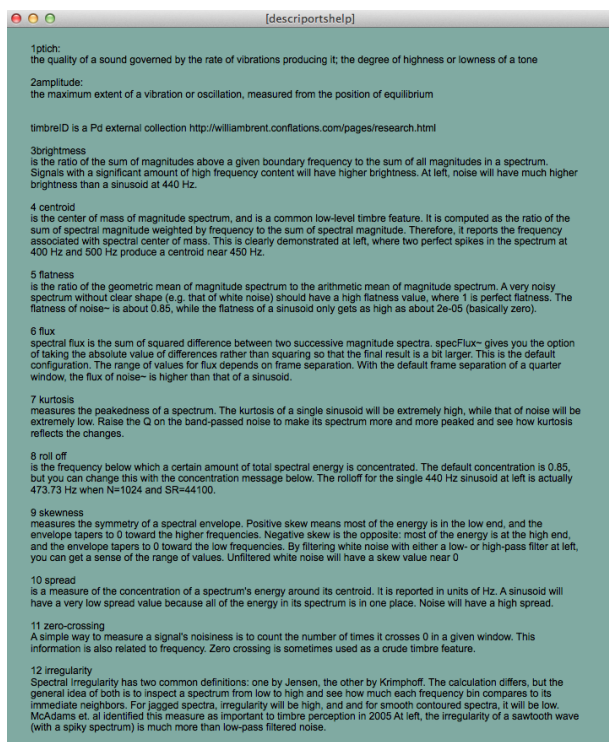


Figure 66 URB-app about descriptors

¹²¹ <http://ptspts.blogspot.com/2009/11/how-to-convert-unix-timestamp-to-civil.html> (Accessed: 26 March 2014)

About URB

This is an informative window (Figure 67) that briefly describes the URB project, URB-app, academic context and advisors, technical credits, institutional funding for the investigation project, artistic partners and support, and the creative licence of this software (Creative Commons Attribution-NonCommercial-ShareAlike¹²²)

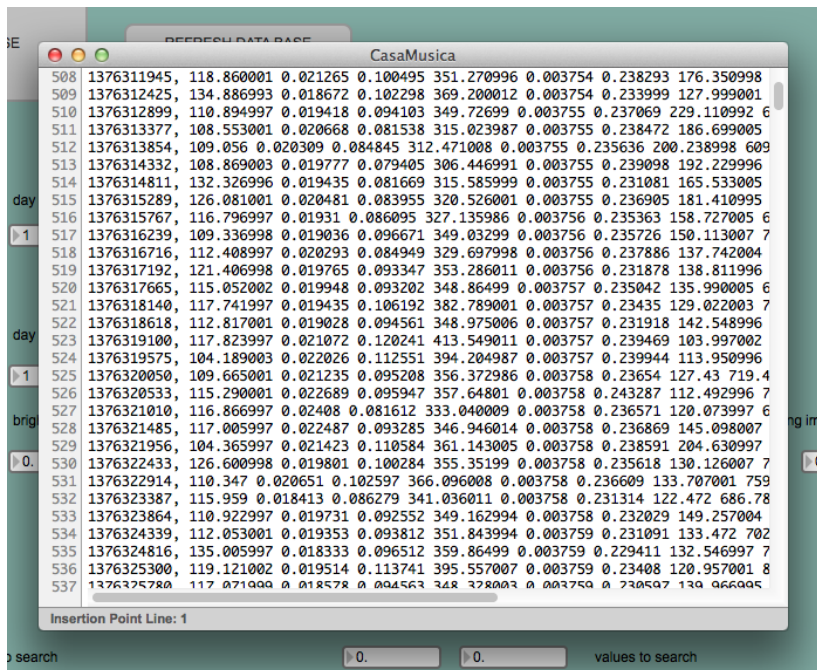


Figure 67 URB-app about window

Listening Points window

This part of the software is for interaction with the URB database and is similar to the four listening points. By default when a window is open, the database of that specific listening point is loaded from the server to the computer and a window with the raw data pops up (Figure 68).

¹²² <https://creativecommons.org/licenses/by-nc-sa/4.0/> (Accesed: 28 March 2014)



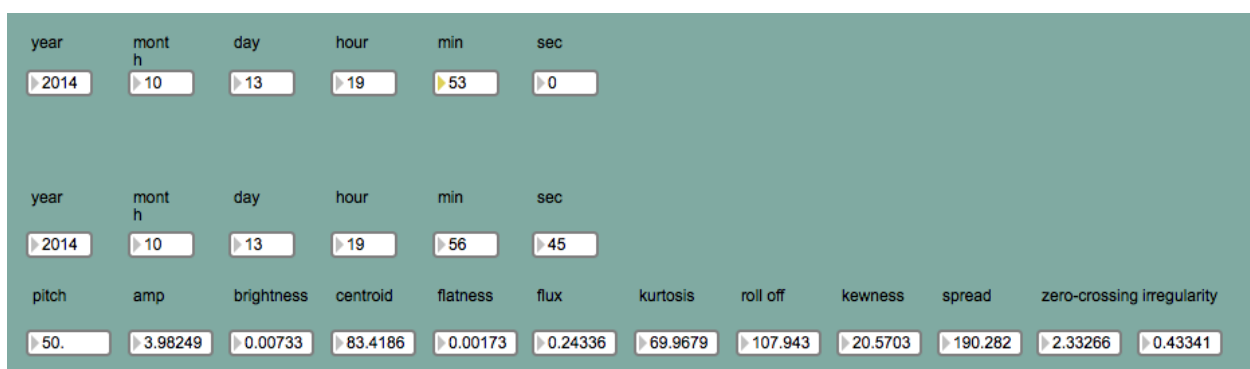
The screenshot shows a window titled 'CasaMusica' displaying a list of data points. Each row contains a line number (e.g., 508, 509, 510) followed by a series of numerical values. The values are organized into columns, with some columns having headers like 'day', 'brigt', and 'ng lres'. The data points are listed in a scrollable area, and there are search bars at the bottom for 'search' and 'values to search'.

Figure 68 URB-app raw data window

The window is divided in three sections: search by date; search by value and search between values.

- **Search by date:**

In this section the user inserts a date (year, month, day, hour, minute and second) and the software displays the nearest date available and values of descriptors corresponding to it. (Figure 69)



The screenshot shows the search interface of the URB-app. It features two rows of date input fields (year, month, day, hour, minute, second) and a row of descriptor input fields. The date fields are set to 2014, 10, 13, 19, 53, and 0. The descriptor fields are set to 50, 3.98249, 0.00733, 83.4186, 0.00173, 0.24336, 69.9679, 107.943, 20.5703, 190.282, 2.33266, and 0.43341.

Figure 69 Example of searching by date.

• Search by value:

In this part the user has the possibility to search the database by a value of a descriptor. After the selection of the sound descriptor the user inserts a value and a window appears with all the dates where that value appears with a proximity of five decimal values. (Figure 70)

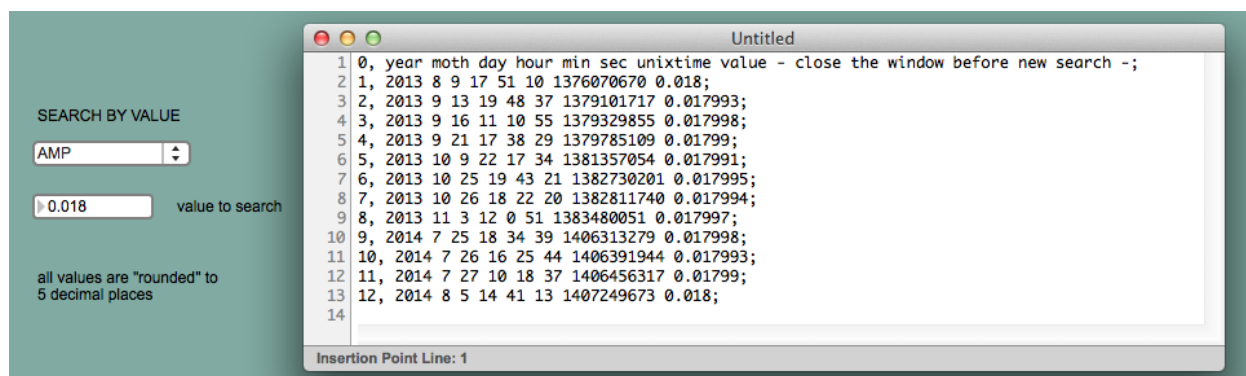


Figure 70 Example of searching by value.

• Search between two values:

This is the third and last possibility to interact with the URB database through this application, which is searching for a value within a defined range. The user chooses the sound descriptor and inserts minimum and maximum values for the search. (Figure 71)

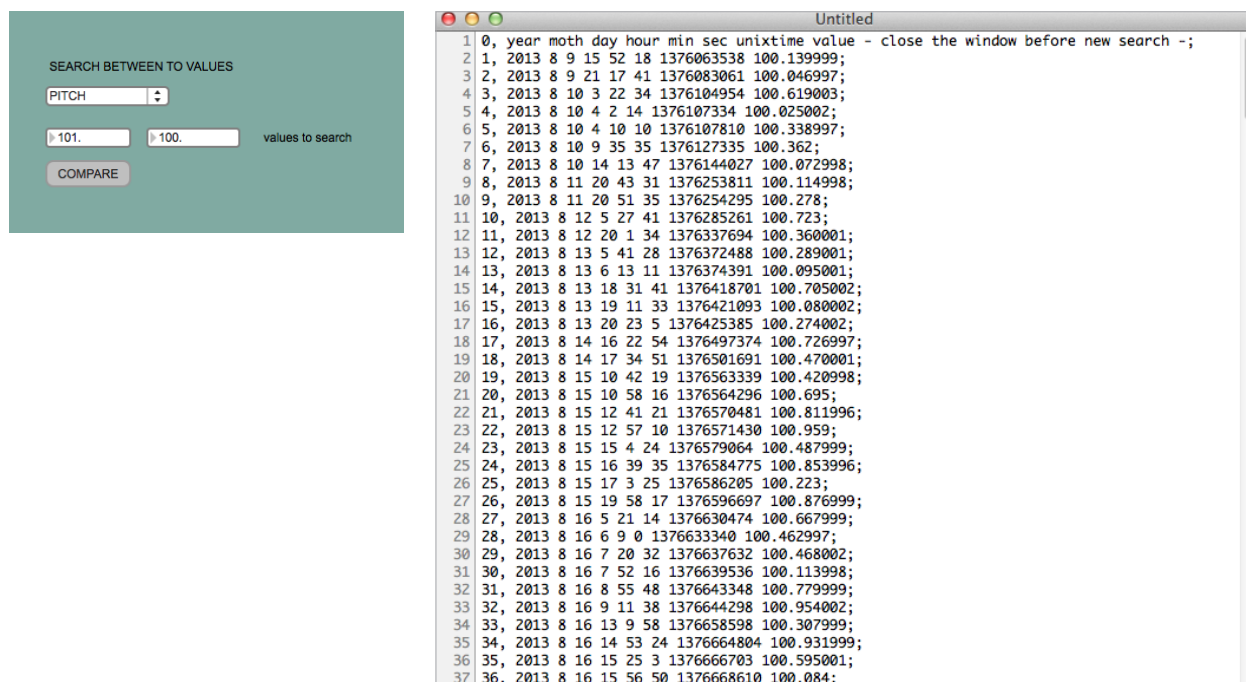


Figure 71 Example of searching between two values.

URB app - Max version

Although this application has a standalone version, the Max version proved to be much more relevant to our project. When some artists use the data for their creations they use this tool not only to consult the database but also as an interactive tool to directly feed their works. So they adapt the patches to use according to their needs, in real-time performances as well as installations, or for composition processes (described in detail in the Chapter 7 - URB artistic applications).

Standalone OSX version: www.jasg.net/URB.zip and Appendix F

Max project version: www.jasg.net/URBv3.maxpat.zip and Appendix F

6.5 Project Website and Graphic Identity

Due to the characteristics and objectives of this project we developed a very simple graphic identity and a website. With these two tools it was simpler and more effective to communicate with the general public and the artistic community, to spread the project and to distribute the contents (database, software, music pieces, and so forth).

6.5.1 Graphic Identity

The graphic identity was developed by the designers Mariana Gomes¹²³ and João Pereira¹²⁴. The work developed is quite simple and consists of a logo and a graphic layout for the website.

The logo is an abstract figure inspired by an urban landscape (Figure 72)



¹²³ www.marianagomes.pt

¹²⁴ www.cargocollective.com/Jp-Portfolio

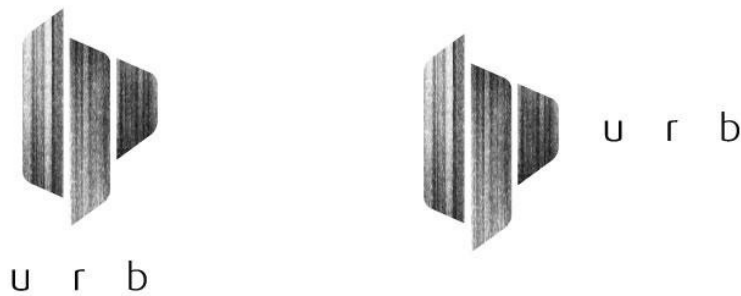


Figure 72 URB logo

The graphic layout consists of a group of rules (e.g.: typography, spacing) to standardise the public content related to project and a group of similar banners, related to the logo, that is used in all the pages of the web site and app. (Figure 73)

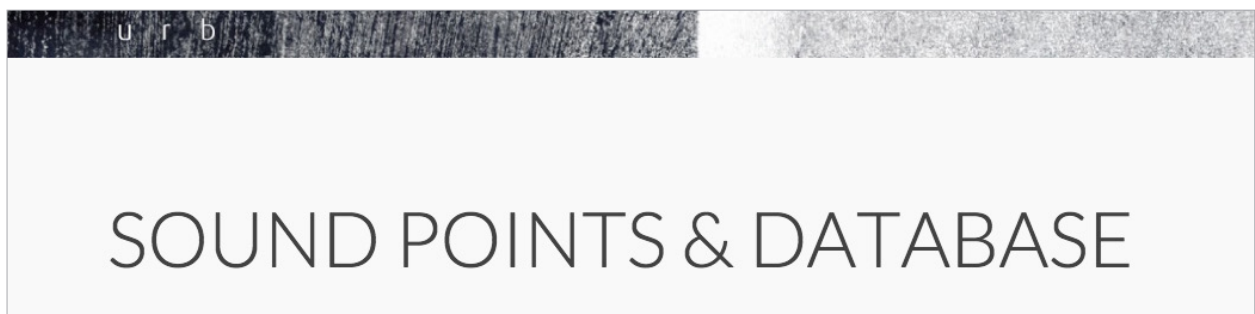


Figure 73 URB graphic identity

6.5.2 Website

The website, with the domain www.urb.pt.vu or www.jasg.net/URB.html, has the main function of describing the project, conceptually and technically, and to be a storage place of the artist and scientific content produced during the project, and finally a window to the database table of the different listening points.

Note: Although the website is not particularly relevant from the research point of view, it seemed important to us his description at this point since it is the main element of this project that establish contact with the public, academic or not.

The structure is very simple being very easy to access the content (Figure 74).

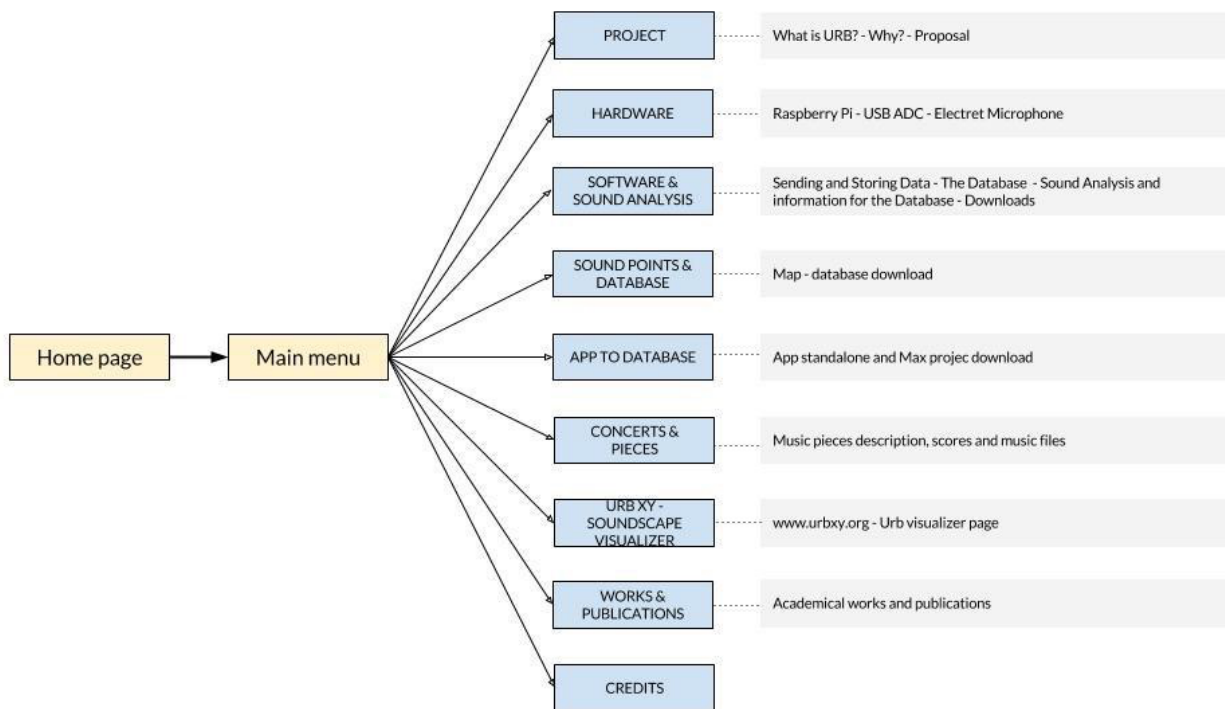


Figure 74 URB project Site Map.

The Home Page window is a page only with the icon of the project and links to the main menu page (Figure 75). From the main menu it is possible to access all the content of the project. Each page is dedicated to a specific subject of the project:

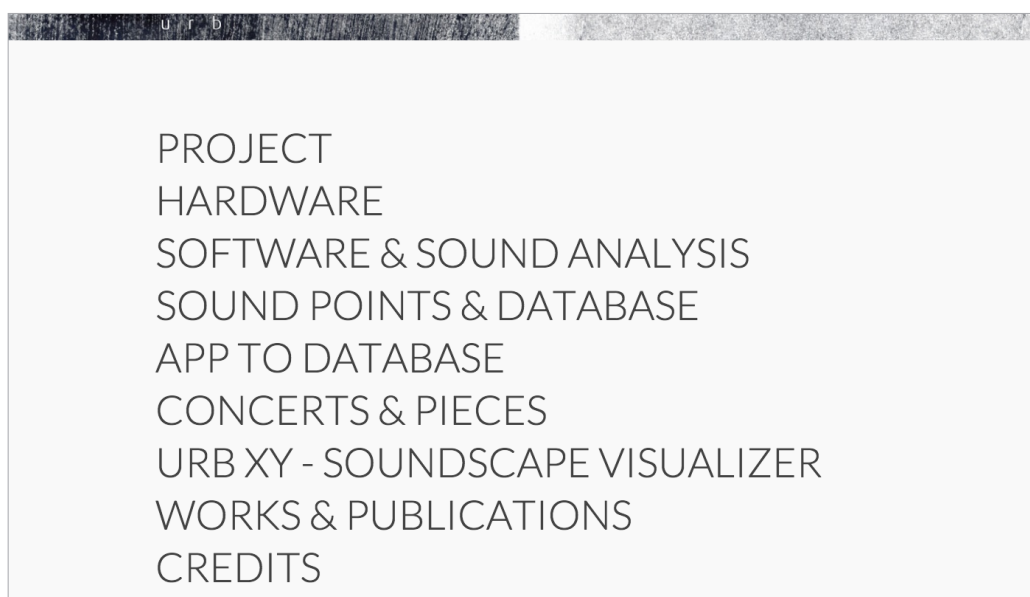


Figure 75 Web site's main menu

- **Project - www.jasg.net/URBproject.html**

This page describes the project concept, its origin and the main purposes and goals.

- **Hardware - www.jasg.net/URBhardware.html**

This page describes the different hardware components used in the project: Raspberry Pi, USB ADC and Electret Microphone.

- **Software and Sound Analysis - www.jasg.net/URBsoftware.html**

In this page we describe the software developed and used in the listening points, the process of sound analysis and the data storage process: Sending and Storing Data, The Database and Sound Analysis and information for the Database.

This page also hosts a fundamental part of this project. A section where users can download all the software developed for in this project: URBbox image for Raspberry Pi (with OS - 2013-02-09-wheezy-raspbian, MySQL, Python, PD extended (with boxv04.pd) and timbreID sounds analysis library), and the Python Script to communicate with the server. It also has a group of external links with help instructions for some obstacles that the user can find during the building process. This section is particularly important not only because it is a path to distribute content, but also because it is a fundamental window to promote the expansion the project and to encourage new variations and approaches.

URBbox image for Raspberry Pi and the Python Script can be found in Appendix E

- **Sound Points and Database - www.jasg.net/URBsoundpoints.html**

This page presents a map of Porto city with the project listening points marked and presents the links to the database of each one. You can choose to open the database in a new browser window and/or to dump it to your computer as a .txt file.

- **APP to Database - www.jasg.net/URBapp.html**

This page has the function of presenting the app and max patch to communicate with the URB database (described in detail in the subchapter 6.4.1 - URB-app description) and the corresponding download links.

- **Concerts and Pieces - www.jasg.net/URBconcerts%26pieces.html**

This page is a repository of all the artistic activities developed that used the URB database in some part of the process. For each work, a music piece or an installation, for example, we present a small text about the process and motivations for the work, the author and the link for his own site and, if applicable, a video with a piece or a link to the music piece.

- **URB XY - Soundscape Visualiser - www.urbxy.org**

This section of the main menu redirects to an external website of the project URB XY. URB XY is a data visualisation software program designed by Diogo Tudela to grant fluid and intelligible navigation through URB's stored data (described in detail in the subchapter 7.6 - URB XY).

- **Works and Publications - www.jasg.net/URBworks%26publications.html**

This part of the web site is dedicated to academic works developed in this project and press releases. What appears is the article title, the abstract, where it was published and if possible the link to the full article. a list of press articles about URB also appears here.

- **Credits - www.jasg.net/URBcredits.html**

In this final page the several participants in this project are listed, and their function is specified. All the institutions that support the project are also referenced (Figure 76).

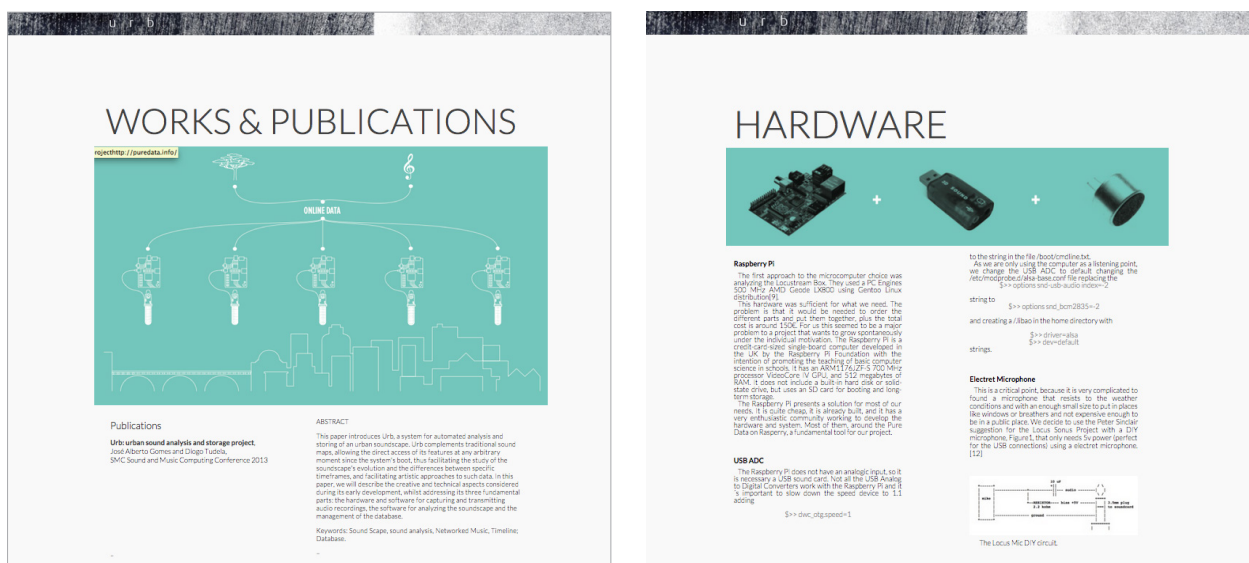


Figure 76 WURB web site examples

6.6 Chapter Conclusion

In this chapter we have presented the design and implementation stages of the prototype system URB, in detail. URB is the tool used in this experimental research. It was not a trivial process as it involved the participation of different areas of knowledge, ranging from machine listening to micro-computing, database, server and network engineering as well as information visualisation. The final product was the outcome of an interactive process, interweaving design, testing tasks and implementation. At every stage, implementation constraints and opportunities defied the original design, forcing us to adapt and think further. For example, we only decided not to only keep the listening points to transmit sound in real time when in our first tests we realised that people's privacy was seriously called into question.

Considering all the qualities and constraints of the prototype, we believe that the design and implementation, both in hardware and software, was successfully achieved in the context of the research purposes. We managed to provide a tool, which, as mentioned, serves the goals of urban noise monitoring, and to be a

medium for artistic application. We reached these goals while maintaining great accessibility, both with cheap hardware and freeware and open-source tools, without compromising the robustness. We also believe, due to the characteristics of the components developed and used in the construction of this prototype, and a strong DIY approach, that this project can promote and help new projects related to these fields.

Chapter 7

URB Artistic Applications

In this chapter a small survey of artistic works that use URB in their creations is presented. A call was open to the music and sound art community to work on the challenge of using URB in the creative process. It could be an electronic piece, music for instruments or a sound installation. The only requirement was that somehow the data from URB had to be used in the composition of the work. Several artists from different backgrounds and with different aesthetic purposes responded to the call.

The main goal of this part of the investigation is to test and evaluate the URB system, regarding its efficacy in the permanent collecting of data from urban soundscapes, as well as regarding access to such information. Other aims, starting from the analysis of the pieces and of the feedback and opinions from the authors, is to assess the relevance of this approach to environment sound as a gigantic sensor to be used in artwork, if this approach is artistically relevant, and if it will contribute to approximate the sound environment and the creator. This investigation also tries to understand if the aesthetic characteristics of the original sound sources are captured within the structures will remain accessible in the final composition, and, from the comparison of the results, hopefully also to start to point towards a way of systematising the artistic approach from the comparison of the results between them.

These works were created by different artists and in different formats. The authors of these pieces were not connected to the previous investigation, so for them the goal was not the process but the final piece and aesthetic achievement.

The four projects presented in detail are:

- ...URB to B... - Composed by Nuno Peixoto. For 2 Percussionists (timpani, vibraphone, and multi-percussion set)
- Rascunho - Composer by Filipe Lopes. For Live Electroacoustic Music
- Control and Unpredictability - Created by Gustavo Costa and Eduardo Magalhães. Sound Installation
- Urban Sonic Impressions - Created by Rui Dias with the collaboration of Gilberto Bernardes. Sound Installation
- (25/04/2013) x 2 - Created by the duo Palmer Eldritch. For Live Electronic
- URB XY - Created by Diogo Tudela. Data visualisation software.
- Re-Interpretação Urbana - Created by Filipe Lopes and José Alberto Gomes. Sound Installation.

Due to the deep involvement in the project, we decided not to include personal creations with the intention not to influence results and conclusions with the expectations previously created.

All the projects presented here had our, very close, monitoring and support on a technical level.

In the case of Re-Interpretation Urban work, this support crossed the border technique invading the creative and artistic field; anyway the reflexions presented in this chapter are unique to the creator Filipe Lopes.

7.1 ...URB to B...

Composer: Nuno Peixoto

For: 2 Percussionists (timpani, vibraphone, and multi-percussion set)

The composed work was commissioned by the Portuguese group Talea et Alaia¹²⁵ to be premiered in a Brazilian tour on January 2014. This provided the perfect setting for the composer to create a piece entirely related and inspired by the characteristic Portuguese sounds. Envisioning this, Peixoto decided to accomplish it through a representation of Porto city. To do so, URB software became the essential tool that granted the necessary data for the elaboration of ...URB to B..., allowing the transition of urban sound to the musical piece.

All the musical material used in this piece derives from the extraction of data provided by URB software. This tool is used by the composer not only at a structural level, but also in pitched notes and rhythmic sequences. Through the arrangement of all these elements, Peixoto intends to capture the particularities of each listening point that characterise and describe the different times of the day in Porto.

Structure-wise, the composer uses solely data belonging to three listening points (of the four possible ones in URB Software): Casa da Música, Oliveira Monteiro/Rua da Boavista and Sá da Bandeira/Mercado do Bolhão. So we have the following structure:

A – Casa da Música (b.1 – 22)

Bridge I (b. 23 – 24)

B – Oliveira Monteiro/Rua da Boavista (b. 25 – 100)

Bridge II (b. 101 – 106)

Development (b. 107 – 128)

C – Oliveira Monteiro/Rua da Boavista (b. 129 – 150/end)

The Sá da Bandeira/Mercado do Bolhão listening point has a very brief part in the ...URB to B... composition, in comparison with the remaining two. Its sole purpose it is to provide a vibraphone motif, which is repeated several times, as can be seen in bars 38, 60, 84 and 127. The second assemblage of the city's characteristics is done through obtaining pitch levels (musical notes) and rhythmic sequences. For this purpose, the composer applies a strategic “reading mode” (Bernardes, Pinho, Lourenço and Guedes, 2012) over just two table indexes (same number of instrumentalists): pitch and centroid. The first one is designated for the timpanist (percussionist 1), due to the low frequency range of the pitch. Lastly, the second percussionist, that plays several instruments such as the vibraphone, is directly related to the frequencies presented on the centroid index table. For the translation from numerical values to musical notation Peixoto developed a process termed Reading Mode.

¹²⁵ Formed by the percussionists Rui Sul Gomes and Nuno Aroso



Figure 77 Excerpt of ...URB to B... musical composition (bar 84)

Soundscape pitch from URB analysis	Reading Mode process to chromatic scale	Reading Mode process to rhythm
493.128Hz	= B3 (493.9Hz)	attack time
440.73Hz	= A3 (440Hz)	attack time
369.36Hz	= F#3 (370Hz)	attack time
414.962Hz	= G#3 (415.3Hz)	attack time
349.419Hz	= F3 (349.2Hz)	attack time
310.825Hz	= D#3 (311.1Hz)	attack time
417.578	“incorrect value”	
330.471Hz	= E3 (329.6Hz)	attack time
308.012Hz	“incorrect value”	
298.537Hz	“incorrect value”	
462.87Hz	“incorrect value”	
235.322Hz	“incorrect value”	
330.471Hz	= E3 (329.6Hz)	attack time
358.298Hz	“incorrect value”	

Table 3 The following table depicts the rhythmic and melodic cell values (Figure 77).

Reading mode: The different values presented in the pitch and centroid tables were divided into two categories. Firstly, we have what we consider as “correct values”, meaning all the frequencies provided by the chromatic scale, such as: 73.4Hz = D1, 440Hz = A3. We also consider as “correct values”, frequencies that are 1Hz above and below the ones presented by the chromatic scale. This means that values such as 329.052Hz are equivalent to the E3 (329.6) note. Other examples of this process are: 83.2682 = E1 (82.4); 92.2924 = F#1(92.5); 104.436 = G# (103.8). (The values that result from these two sound features are within the scope F1 to B3. As such the fact of frequency being a logarithm is not a problem because this process is only applied in a section of low frequencies. The high notes are achieved through octave transposition but always respecting the note) Secondly, we have what we call “incorrect values”, which are the ones that don’t fit the “correct values” standards (Table3). For example: 90.4796Hz, 94,9886Hz, 95.5805Hz, and so on. This category has the task of identifying the duration of a certain “correct value”. Therefore, the more “incorrect values” we find associated to a certain “correct value”, the longer the rhythmic duration of a musical note will be. For example:

219.621Hz = A2 (220Hz)_____attack time

214.381Hz = “incorrect value”

234.848Hz = “incorrect value”

235.523Hz = “incorrect value”_____note end

220.003Hz = A2 (220Hz)_____attack time

221.799Hz = “incorrect value”

242.159Hz = “incorrect value”

289.992Hz = “incorrect value”_____note end

292.947Hz = D3 (293.7Hz)_____attack time

304.007Hz = “incorrect value”

308.547Hz = “incorrect value”

326.367 Hz = “incorrect value”_____note end

If the value determined for each Unix Time unit represents a semiquaver, then the previous values represent the following rhythmic figuration: ♪♪♪, with the respective pitch of A2, A2 and D3. The previous example was extracted from Casa da Música’s listening point, with the corresponding index time of 1376118294 (2013-08-10 07h04:54).

In the musical composition ...URB to B..., the value assigned for each input/Unix Time is of 250ms. Therefore, the shortest rhythmic value provided by this reading mode will be the semiquaver.

After establishing this algorithm, it was necessary to develop a new URB version in order to interpret the currently reading mode and allow it to communicate with a MIDI sequencer, thus making it possible to convert the URB tables for automatic music notation.

The full score can be found in Annex A and www.jasg.net/URB/URB_to_B.pdf

7.2 Rascunho

Composer: Filipe Lopes

For: Live Electroacoustic Music

According to Lopes, the main issues that emerged upon the proposal was: “why should one analyse a given soundscape as such, especially when targeted to music composition?” Intuitively it seems more expressive and interesting to use concrete sounds of the soundscape rather than its analysis. Nevertheless, Lopes was curious about what could be revealed by such data and to find if he would be able to use it in a formalised composition, since the combination of both does not necessarily mean interesting music.

The first experiments were focused on retrieving the online data, connecting it to oscillators and hearing the results, in a very empirical approach. Later experiments evolved into controlling broader parameters such as wet/dry reverb, faster or slower pulses (e.g. using the feed to control a metronome), extended or compressed harmonic fields (e.g. upon a chosen chord, use the feed to expand, compress or transpose that chord). The initial experiments were accomplished retrieving the values at slower rates, such as a value each second. Overall variations, however, ranged from 500 milliseconds to 5 seconds. In the prior approaches, Lopes was evaluating the feeds number by number, assessing the sonic discourse between successive values, evaluating them “by ear”.

A different approach later taken was to extract the numbers very rapidly, in order to create a movement perceived as a gesture of the feed, which he used to assess its potential as melodic lines or rhythmic contours. Lopes did such experiments retrieving values at fast speeds such as a value every 100 milliseconds or even faster.

At this time, Lopes was yet not convinced about the sonic outcomes. It all sounded unnatural. Melodies didn’t have a melodic contour, rhythms didn’t relate to each other and using URB to change any given parameter also raised the question of what sound to use, since URB, just like MIDI, does not “sound”. Globally, URB provided values that had no musical feeling between them, at least in Lopes preferred domain: formalised electronic music.

Lopes’s aim to use URB’s data values had to match a valid inevitability in order to make them different to a random generator. This was especially important since the descriptors were sound indicators with possible expressive sonic significance. Unlike sonification environments where a composition is often based on non-musical data (e.g. Omega – uma narrativa de sonorização e visualização (Lopes and

¹²⁶ POLISphone is a versatile sound map. It aims to be a flexible interface, both graphic and sound wise, and to induce a sense of instrumentality. It starts in Portophone mode, but users can quickly use their own images and sounds to play POLISphone. Any user is also able to draw his own maps, define his own sound spots as well as save/load any POLISphone. <http://vimeo.com/85330001>

Menezes, 2012)), URB is based on extracting musical features from soundscapes, which has been a long and proved topic of many compositions.

The work *Rascunho* was played live as opposed to a fixed electronic composition. It emerged by the division of URB's feeds between "high-variation" and "low-variation". For the piece, Lopes also decided to use concrete sounds of Porto, playing them with the software POLISphone¹²⁶. The form used was the classical: A B A. Part A: Lopes used his older composition *Different Shapes, Same Rhythm* multiplied five times and used URB values to change its playing speed. Some of the values controlling playing speed were "high-variation" and others were "low-variation". This produced an organic drone but with a pitched feeling, as the composition itself is played on a piano. In addition, some values of URB were feeding a simple sine wave generator, masked with reverb. Towards the end of this section, the concrete sounds of Porto were introduced, and all the other sounds were faded out. Part B: was comprised of very subtle concrete sounds such as night soundscapes or museum gardens and no URB usage. The use of concrete sounds of Porto seemed to fit the piece and the context proposed. The return to part A, was accomplished again with a fade-in, recycling most of the materials, and URB's usage. The final section, or coda, comprised the stopping of each sound-source one by one until, at a slow rate, until the music reached silence.

Rascunho: www.jasg.net/URB/Rascunho.mp3 and Annex B

7.3 Control and Unpredictability

Composer: Gustavo Costa and Eduardo Magalhães

Sound Installation

The sound installation used audio recordings and URB data from the Carvalhido listening point. It explored the subjective interpretation of the listeners, especially when confronted with sounds that were embedded in their own particular geographical and social references. Since the parameters extracted from URB were highly objective, this piece relied precisely on the confrontation of objective and subjective data.

Control and unpredictability consisted of:

- A loudspeaker inserted into the resonant body of a floor tom;
- A drum membrane with sand over it (Figure 78);
- Two loudspeakers playing processed field recordings from the Carvalhido area (spectral filters and time stretch previously processed with the Kyma software).



Figure 78 Control and Unpredictability sound installation

Two URB parameters were used as input values for a Max MSP patch. These inputs acted as triggers for melodic and harmonic content. Input 1: Centroid values Input 2: Amplitude values.

Centroid provided frequency values that were translated into pitch class sets (from 0 to 11), which were then transposed randomly to different octave registers to be played by a virtual instrument (a celesta). The values were then filtered to prevent the occurrence of some undesirable intervals. Only notes from a whole tone scale would be played, and unisons, octaves and perfect fifths were blocked. Amplitude values provided a trigger for the processed field recordings after a defined threshold. Since the original values were triggering too many sound events, a rescaling of the values was made in order to become musically adequate.

The sound of the virtual celesta was played by a loudspeaker inserted into a floor tom. Over the membrane of the drum was some sand that was being excited when certain frequencies induced the vibration modes of the membrane. Since there was also a light inserted inside the floor tom, the sand created different visual patterns according to different vibration modes of the membrane.

There were many layers of transformation of the natural soundscape of the Carvalhido listening point. The natural sounds analysed by URB, audio recorded, digitally processed, recombined with a melodic layer provided by URB data and ultimately recombined again with its natural sounds, since the sound installation was on an open-air space. Regarding URB, some of the values were translated musically in a way that they became impossible to have a direct identification with the original sources. However, there was an extremely important level of conceptual coherence that was obtained while mixing the objective URB data and translating it into a subjective, and sometimes distorted, musical reality.

7.4 Urban Sonic Impressions

Composer: Rui Dias with the collaboration of Gilberto Bernardes.

Sound Installation

“Urban Sonic Impressions” is a sound installation inspired by the URB system that creates moving sound textures using sounds from the Porto Sonoro sound archive. Using the analysis data from the online stream coming from the four URB locations in Porto, the data is used to continuously select and alter the parameters of four granular synthesisers and processors (Figure 79). Implemented in the Max/MSP/Jitter environment, the data is retrieved and mapped to four audio processor parameters to determine the resulting sound for each one. The audio processors consist basically of granulators and spectral FFT processors. Using the earGram¹²⁷ concatenative synthesis software by Gilberto Bernardes, a selection of sound recordings from the Porto Sonoro online archive were analysed and segmented according to the brilliance and amplitude descriptors. The segments were then reordered into a “scale” of sound grains forming a continuous sound file that starts with the segments with the lowest brilliance values and ends in the segments with the highest values. In order to obtain a greater sonic diversity, for each of the four different locations, a different set of sounds was chosen.

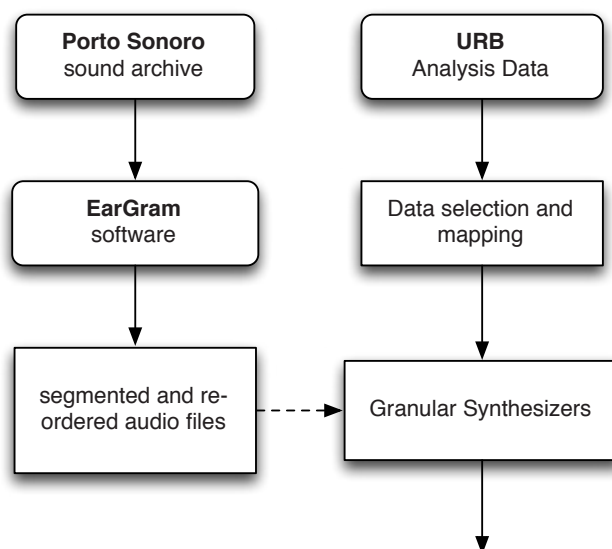


Figure 79 Workflow diagram

¹²⁷ earGram is software for interactive exploration of large databases of audio snippets. It was developed by Gilberto Bernardes (FEUP, SMC Group - INESC/TEC) in Pure Data. earGram extends concatenative sound synthesis to embed generative strategies as selection procedures and aims at exploring creative spaces with reduced user interaction. (Accessed, 10 April, 2014).

Because all four listening points are set in city streets, the real sounds that are analysed are not necessarily very distinct. However, the locations have some relevant landmarks that were used as metaphors for the selection of the sound material. As such, while the selection of sounds for the “Sá da Bandeira” and “Oliveira Monteiro” streets were regular city sounds that include all sorts of vehicles, noises, voices, and so on, the sound selection for the listening point in “Casa da Música” includes musical instruments, and the “Sonoscopia” location includes sounds from several percussive and metallic objects, seldom used in the venue’s music concerts and sound installations.

After the segmentation and re-ordering process with EarGram, the resulting sound files are then loaded into the granulators, and the current URB brilliance analysis feature is mapped to the buffer read position.

Other audio processors are used to provide more richness and variation, namely FFT filters and resonators. The amplitude and spread features from URB control the amplitude of the filter and resonator modules respectively, while the pitch defines the base frequency for the resonators module.

The resulting sounds are then arbitrarily positioned in a four speaker square configuration around the space (Figure 80). Each of the four sound locations is placed in a speaker pair corresponding to one side of the square.



Figure 80 Source spatial position configuration

7.5 (25/04/2013) x 2

Composer: Palmer Eldritch (Luís Fernandes and Miguel Pedro Antunes Guimarães)

For: Live Electronic-Acoustic

(25/04/2013) x 2 is a real-time manipulation of the data provided by the URB system captured on April 25th of 2013 using an analog synthesiser:

- Modular synthesiser in eurorack format (modules: Make Noise, ADDAC, Mutable Instruments, Doepfer and Intellijel)
- Arturia Minibrute
- Doepfer Dark Energy

The music project Palmer Eldritch is a duo based in Braga (Portugal). They explore electronic music using microscopic textures, dreamy synths and danceable beats in a non-danceable context. Contrary to the other projects presented in this chapter the authors have no formal education in music composition and are not involved in the musical academic area. However, it is a project of recognized value by the musical community, being actively involved members in artistic creation in various musical and aesthetic types for several years. This fact is quite relevant and interesting for this investigation in order to understand whether this approach serves less formal and trained musical styles, and how that different approaches may be.

This piece, as is well highlighted in the title, uses the data captured from the 25th of April 2013¹²⁸. For the work two listening points are chosen, Sá da Bandeira/Mercado do Bolhão and Casa da Música, one for each musician.

The music piece is divided into three sections characterised by speed and note release:

- A** Moderate speed and short note release
- B** Fast speed and short note release
- C** Slow speed with long note release (with extra sound processing)

The sound descriptors used in this live performance were pitch to control the Pitch of the synthesisers and the Amp descriptor to control the envelope release parameter.

¹²⁸ This date is particularly important for Portugal because it is the anniversary of the Carnation Revolution. A military coup in Lisbon, Portugal, on 25 April 1974 which overthrew the regime of the Estado Novo. This event effectively changed the Portuguese regime from an authoritarian dictatorship (the Estado Novo, or “New State”) into a democracy.

Using a Max patch to read the sound data information from the 25th of April 2013 the values from the Amp descriptor were scaled to match the release values and the pitch values were converted to MIDI (Musical Instrument Digital Interface) values to control the Arturia and Doepfer synthesisers and converted to voltage to control the modular synthesiser.

The time line progression was totally respected. So the piece begins with the first line of data and continues progressively from that, line after line. The only structural parameter that was controlled by the musicians in real-time, was the speed of descriptors progression. Meaning that the time lapse corresponding to the entire day was not scaled to the piece's time. The speed was changing under the impetus of the musicians according to their musical taste.

(25/04/2013) x 2: [www.jasg.net/URB/\(25-04-2013\)x2.mp3](http://www.jasg.net/URB/(25-04-2013)x2.mp3) and Annex D

Note: Rascunho, Control and Unpredictability, Urban Sonic Impressions and (25/04/2013) x 2 were presented in the event “We, the citizens” at Future Places Festival 2013¹²⁹

Rascunho, Control and Unpredictability and Urban Sonic Impressions video: www.jasg.net/URBconcerts%26pieces.html or <http://vimeo.com/jasg/URB-wethecitizens> and Annex D

7.6 URB XY

Composer: Diogo Tudela

URB's data visualiser software

The new media artist Diogo Tudela answered the call with a different format than a classic or regular art piece. Being right in the centre of a new generation of programmer-artists (or artist-programmers) movement, where the artistic concept boundaries are often blurred and challenged, the author presented a visualise to URB's data named URB XY.

URB XY¹³⁰ is developed in the open source programming language Processing. It is a data visualisation software program designed to display the sound metadata stored by the URB project and to grant fluid and intelligible navigation through URB's stored data. Providing interactivity to URB's static and orthogonal tables, URB XY allows its users not only to explore the recorded material in its individuality, but also to grasp its overall contours.

¹²⁹ FUTUREPLACES takes place in Porto, Portugal. It is a meeting of people with one question in mind: if digital media can do so much for global communication, knowledge and creativity, how can it contribute to local cultural development? www.futureplaces.org/we-the-citizens/ (accessed, 2 November, 2013)

¹³⁰ URB XY is an experimental software program in beta version, only available to OSX. An on-line version is being developed.

The software starts with a very simple interface where there is always a grid, representing an horizontal time line, and were it is possible to choose the data location or see the evolution of the records loaded of that specific place. (Figure 81)

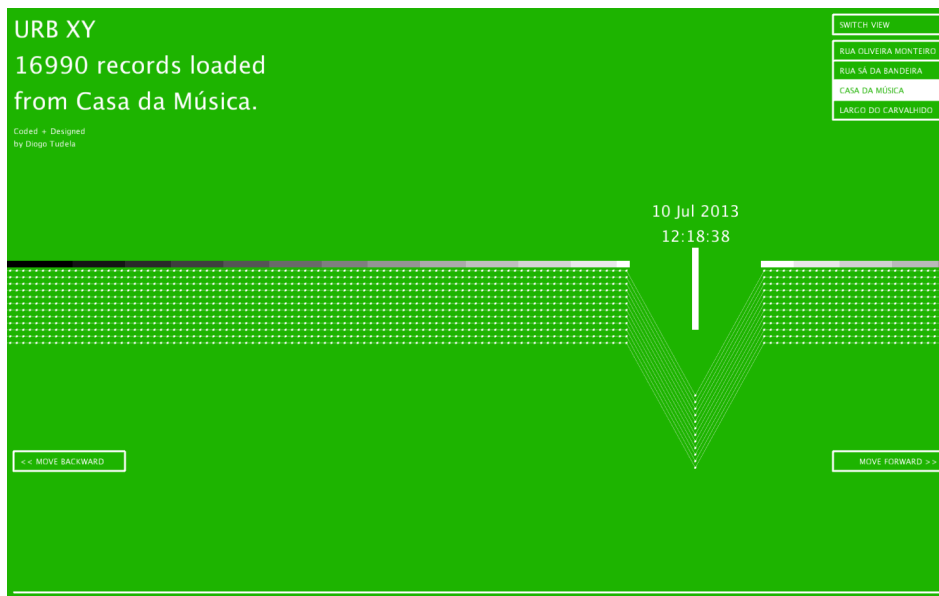


Figure 81 URB XY starting interface

Its interface allows the user to move back and forward in time, while browsing through URB's complete online public database and hovering through the grid displays the sound descriptor and the corresponding data stored in the database. (Figure 82)



Figure 82 Descriptor and data in URB XY grid

The software presents a greyscale section on top of the grid that shows the time of the day in which the recording took place by making a chromatic reference to daylight.

In addition to the default frontal view, URB XY allows the rotation of the grid into a side view, while transferring the database information to a small table at the bottom of the screen. This view was designed to display the behaviour of features over time. This specific view is quite useful to perceive the evolution of the sound during that period of time, not only through a single a descriptor but the sound as a all because is possible to visualise more than one descriptor at the same time, enabling the possibility to analyse the behavioural relationship between various elements (Figure 83).

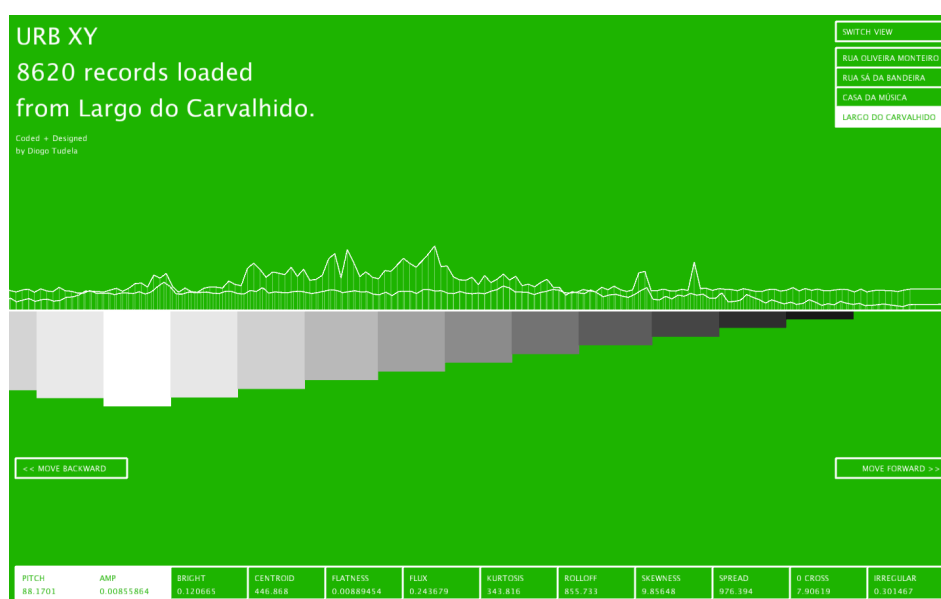


Figure 83 URB XY side view

At any given time, it's possible to refresh the stored data or download information from another location, allowing the comparison of the behaviour of specific descriptors between two different places.

URB XY site and download: www.urbxy.org

URB XY presentation video: www.vimeo.com/87868012 and Annex E

7.7 Re-Interpretação Urbana

Composer: Filipe Lopes and José Alberto Gomes

40-hour Sound Installation

Re-interpretação Urbana (Urban Re-interpretation) is a sound installation which inhabited the chapel during the Serralves em Festa 2014 Festival. This work was commissioned by the Serralves em Festa 2014 Festival¹³¹, the biggest contemporary artistic expression festival in Portugal and one of the largest in Europe, and the Sonoscopia Associação Cultural.

This sound installation has a special meaning for this research because it marks one year of the first installation of an URB listening point, allowing for a one-year time-window approach for the first time. Additionally it seemed to be a perfect opportunity to compare processes already used in order to analyse the sustainability and relevance of artistic processes.

The context of this festival is very particular. Although it is a festival with a contemporary and experimental aesthetic, it is a 40 hours non-stop event with a major impact on the general public, being visited by thousands of people in a very small amount of time. The space chosen for the intervention was a big white room on the second floor of the Serralves chapel illuminated by a huge round window.

Drawing on the physical and symbolic space the authors decided to develop a contemplative sound experience, promoted through an immersive soundscape that mirrors the sonic complexity of the city, particularly its behaviours and patterns, also exploring the room's acoustics.

Being a large impact event in the city, thus creating a specific soundscape on those days, it seemed promising to use the material of the exact same days of the festival from the year before. The public experienced an artistic sonification of the city from exactly the same time of the previous year. The process used was exactly the same used in the music piece *L'abre des Songes* (work described in detail in the subchapter - 4.3 - *L'abre Des Songes*). Although in *L'abre des Songes* all the information was compressed into 6 minutes, in this case the time lapse was fully respected, which represents a significant difference. As used in the original piece, i.e. *L'abre des Songes*, the pitch sound feature information was used to control a simple oscillator. The resulting soundtrack was chosen to be the background sound of the installation. Additionally we used a very basic random midi note generator with only three variables: low limit, high limit and note density. The notes range was controlled by a combination of the centroid and the spread features (providing us the spectral centre and its limits), and the loudness feature controlled note density.

¹³¹ <http://www.serralves.pt/en/museum/serralves-em-festa-2014/>

The system consists of two loudspeakers, approximately the height of a person, front to front, creating a hotspot aligned with the centre of the round window, thus creating a perfect harmony between the sound and the space (Figure 84).



Figure 84 Re-interpretation sound installation

This reworked soundscape was occasionally interrupted, 4 times a day for 15 minutes, with a sound composition by Filipe Lopes. The intervention focused on exploring the acoustics of the room (especially the resonance frequencies) to expand “sound everywhere,” as opposed to a sound concentrated at the centre.

The experience between *L’arbre de Songes* and *Re-Interpretação Urbana* is considerably different mainly because of the format, one is a music piece and the other one an installation. The evolution of the day’s characteristics is more perceptible in the music piece since it is in a kind of fast forward, while in the installation, the direct relation with the soundscape, although less obvious, is more immersive. It can be concluded, however, that different days and locations using the same approach, capture, analysis and compositional treatment, can envisage artistic, meaningful experiences that are reasonably unique.

Re-interpretação Urbana Video: <http://vimeo.com/jasg/re-interpretacao> and Annex F

7.8 Chapter Conclusion

URB proved to be efficient in the access to audio descriptors data retrieved from sound environments, particularly to its time alterations. It also provided composers enough raw material in order to devise their works in addition to a higher awareness about sound environment. The artistic outcomes analysed point to diverse realisations about the aesthetic significance of using URB's raw data. While Peixoto, Costa, Dias and Palmer Eldritch duo guaranteed musical elements such as melodies, rhythm or formal coherences, Lopes claimed that his instinct as a composer induced him to adopt URB's metadata as a 'variation source', free from the descriptors significance. Such as in Lopes' approach, even if the work is artistically interesting, this kind of application can also be verified in the piece (25/04/2013) x 2 where the duo applied the amp values in a different musical parameter.

From a sonic point of view before this small survey of works we can notice similar uses and processes to the data. Most of the artists apply the descriptors in corresponding musical elements, such as pitch, rhythm, and structure; there is also an appeal, on a smaller scale, to use metadata as a 'variation source' apart from the descriptors significance. However there is a similar approach separate from the aesthetic and academic origin of the artist.

URB's data visualiser software, whilst not completely an artistic result by itself, shows the potential applications of soundscape data in other artistic areas beyond music and sonic arts.

Chapter 8

System Evaluation and Result Analysis

In this chapter we present the evaluation of the system from the perspective of the artists that used URB to develop creative work. The analysis presented here is grounded in the questionnaire results submitted by the users.

We start by deconstructing and explaining the different sections of the questionnaire, clarifying what information we aimed to acquire and why. Although this part of the chapter could also be exposed in the methodology chapter, we are sure that presenting it at this stage, after the artistic applications of the system, provides the reader with a better understanding of the questionnaire and the results.

8.1 Questionnaire Design

A questionnaire is a research tool widely used in scientific research, particularly in those that involve human factors. In this study a first person, subjective user experience evaluation was used. Designing a questionnaire is an important process that must be done with due attention, in order to formulate questions that lead to useful data.

The questionnaire is composed using twelve questions with the majority having a five-point Likert-scale¹³².

8.1.1 Introduction – Respondent Identification

This section has the function of collecting basic identification elements from the participants. The information asked is: name, age and artistic background (Information like gender or nationality, quite normal in this kind of questionnaire, were not requested because they would be completely irrelevant to the goals of this study). Although the questionnaire is anonymous (i.e. the identification of respondents is not made public), it is important to collect users basic identification to facilitate the information process.

¹³² Likert-scale is a rating system, used in questionnaires, that is designed to measure people's attitudes, opinions, or perceptions. Subjects choose from a range of possible responses to a specific question or statement. <http://www.britannica.com/EBchecked/topic/1085454/Likert-scale> (accessed, 25 November, 2014)

8.1.2 Section One – URB Technical Usability

This section has the function of evaluating the technical characteristics of usability, with special focus on the access to URB, and use of the database, from the user's point of view.

The questions in this section are:

- What was the degree of difficulty in the accessibility and consultation of the database?
- What was the degree of difficulty of the technical application of the data in the creation of the work?
- Which tool was used to access the database?

8.1.3 Section Two – Personal Choices

The goal of this section is to characterise the way how artists have used the data made available by the system.

The questions in this section are:

- How was the data used?
- How many sound descriptors were used in the final work?
- How many listening points were used for the final work?

8.1.4 Section Three – Artistic Choices and Perspectives

In this section information to characterise some artistic options of the participants is gathered. The aim is not create a general picture of the artistic processes of the authors, but to focus on the points that are intrinsically linked to this research and questions presented previously in this study, like if there is a final work format more suitable for this approach, or the correlation between the original soundscape and the final art piece.

The questions in this section are:

- What is the format of the final work?
- Did you use soundscape sounds in the final work?
- What was the degree of ease of the conceptual application of the data in the artistic environment?
- Before this approach, to what degree did the final work fulfil initial expectations?
- What is the degree of proximity between the original and final work soundscape used?

8.1.5 Section Four – Personal Opinion

This section is comprised of only one question in which we address the opinion of the participants. This question is the only one that does not offer a Likert-scale solution, requiring the participant to develop a brief reflection. This section approaches the main issue of this thesis directly, and the hardest subject in which to present a conclusion: the relevance of this approach. The importance of this question is amplified because the answer could condition all the conclusions of the previous issues: if we conclude that the approach is not relevant, even if URB is technically responding to the artist's need, it is nearly irrelevant.

The question in this section is:

- Is the artistic result of this approach relevant? Why?

The questionnaire given to the users is presented in Appendix G – Questionnaire used in URB research

8.2 Data Evaluation – Questionnaire

In this point we present the results of the data collected through the questionnaires answered by the 8 participants. The information is separated in three logical groups.

The parts are:

- User characterisation
- Technical usability
- Artistic Choices and Perspectives

8.2.1 User Characterisation

- **Age**

The participants are concentrated in an age group ranging from 27 to 48 years old, with higher incidence in the mid 30's. This minimum age is easily explained with the artistic and background requirements to participate in this study. The fact that there are no participants over 48 years old is not at all clear, which could be explained by disinterest in the subject, little relation to the technologies in use, or even poor connection with the sound art channels and communities (Figure 85).

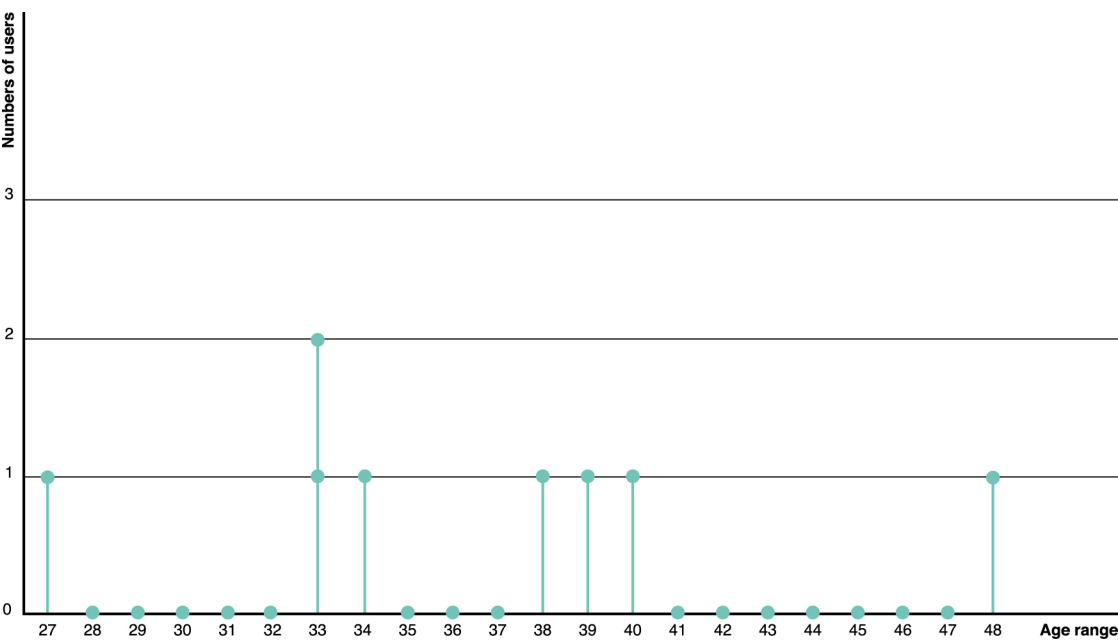


Figure 85 Age distribution of the users

• Artistic Background

To participate in this study having an artistic background in Sonic Arts and an artistic curriculum recognized by the community were requirements. As such this issue serves to categorise the artistic experience and background of the users prior to this experience in greater detail. We can verify a greater concentration of musicians and a lower percentage of artists with origins in the visual and digital arts, there is however enough variety to give a more encompassing response. Participants could indicate more than a single background (Figure 86).

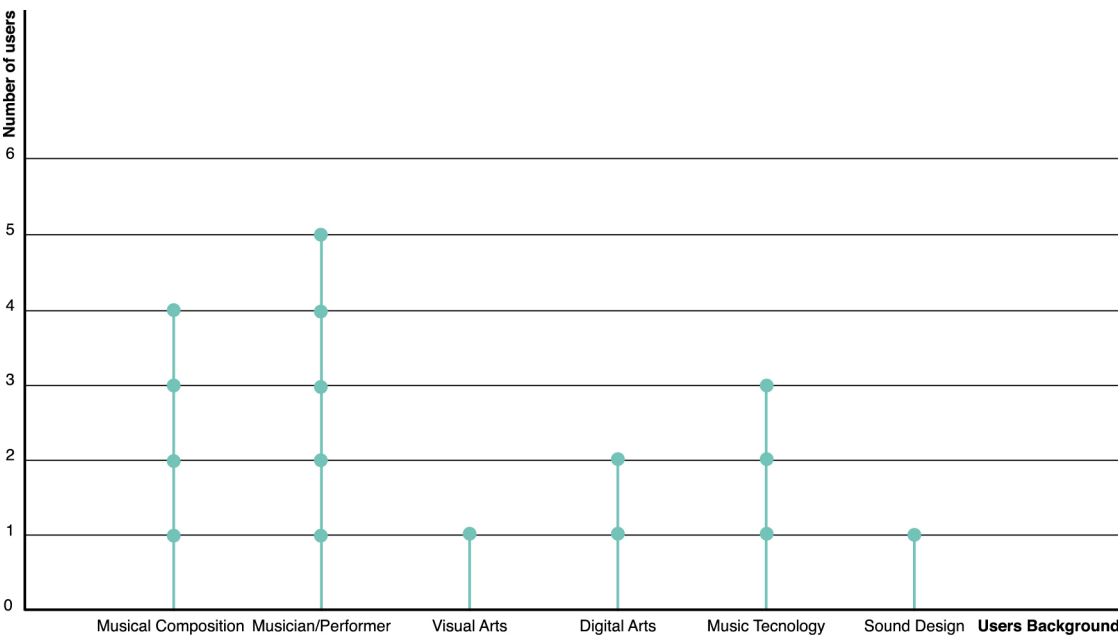


Figure 86 Age distribution of the users

8.2.2 Technical Usability

At this point we analyse the results from the questions, regarding the user experience, on the URB system's technical usability.

- **The degree of difficulty in the accessibility and consultation of the database**

More complicated than the technical process of storing information in the database is to make it accessible. Every day URB stores a huge amount of data, but all that information is useless if it is inaccessible and difficult to use. During the development of the project we were aware that this would be a critical point. The response of the users was quite categorical in proving that the accessibility and consultation of this information is reachable without a major effort (Figure 87).

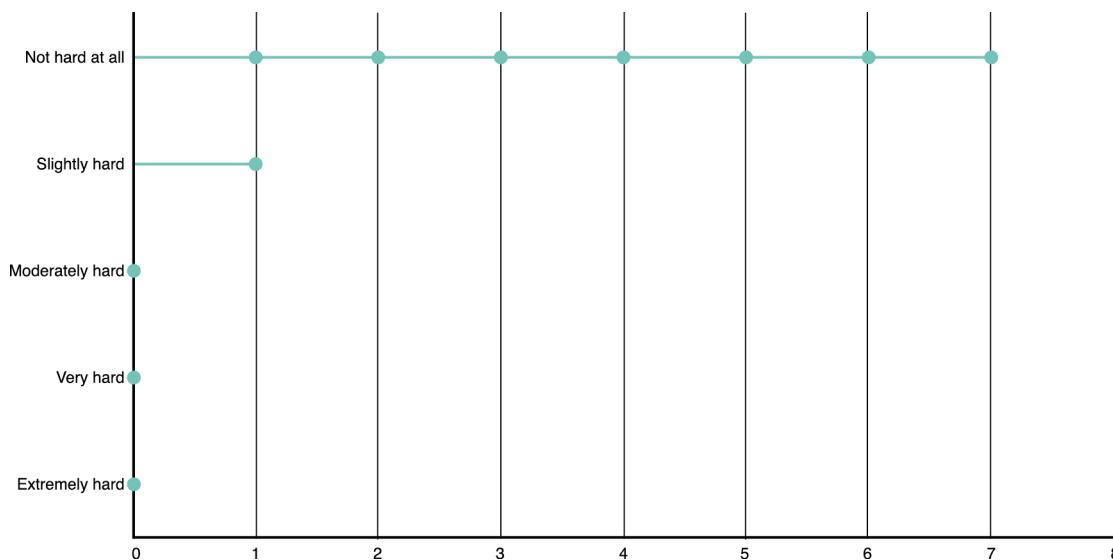


Figure 87 The degree of difficulty in the accessibility and consultation of the database

- **The degree of difficulty of the data's technical application in the work's creation**

Staying on the same subject of the previous question after the consultation, this point has the function of understanding what the difficulty in the technical application of this information in the creative processes was. There was not an overwhelming positive response to question, the majority of the users did not feel any difficulty in this process and none felt significant difficulties (Figure 88).

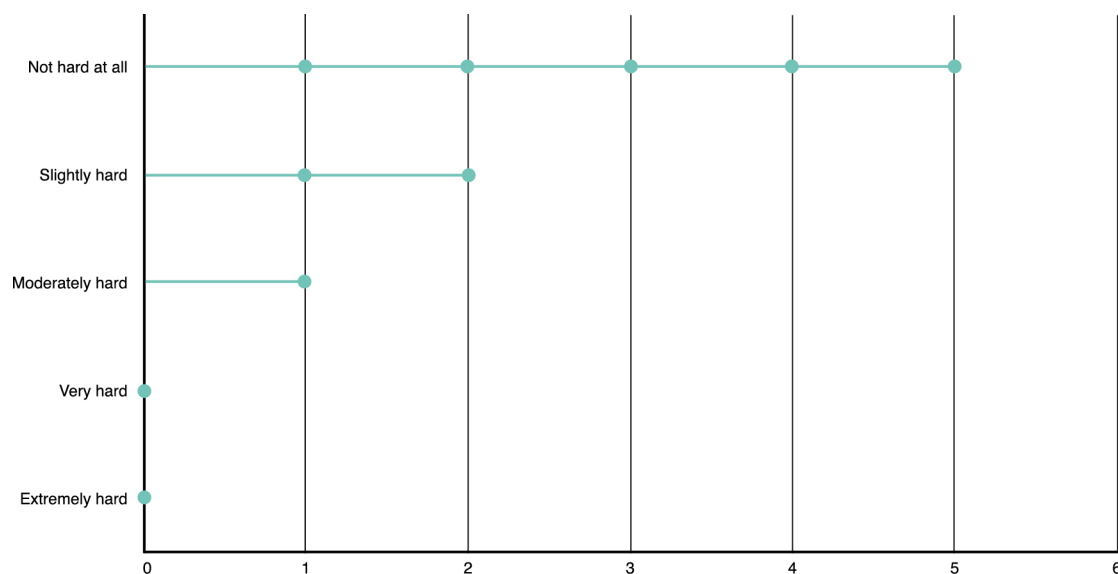


Figure 88 The degree of difficulty of the data's technical application in the work's creation

• Tool used to access the database

Directly related to the previous question, and since flexibility is a key parameter in our project, we found that with regard to the tool used, there was a great diversity. This shows that flexibility is important when it comes to tools in the creative process. The advantage is that we managed to increase the scope of potential interest (Figure 89).

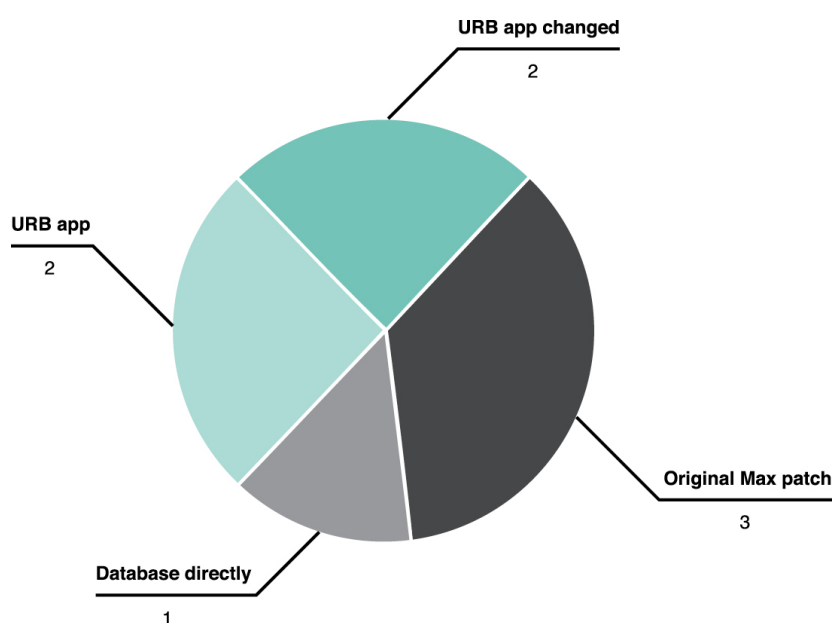


Figure 89 Tool used to access the database

8.2.3 Artistic Choices and Perspectives

In this final section we analyse the results from the questions, regarding the user's artistic decisions with the URB data and conclusions.

• Data Use

The time perspective was one of the main elements that we wanted to approach in the soundscape analysis and storage. As such it is important to understand if the artist's choose a real-time approach or work with a greater time scale. The majority of the users choose not to use the information in real-time in order to put a greater piece of time in a single work (Figure 90)

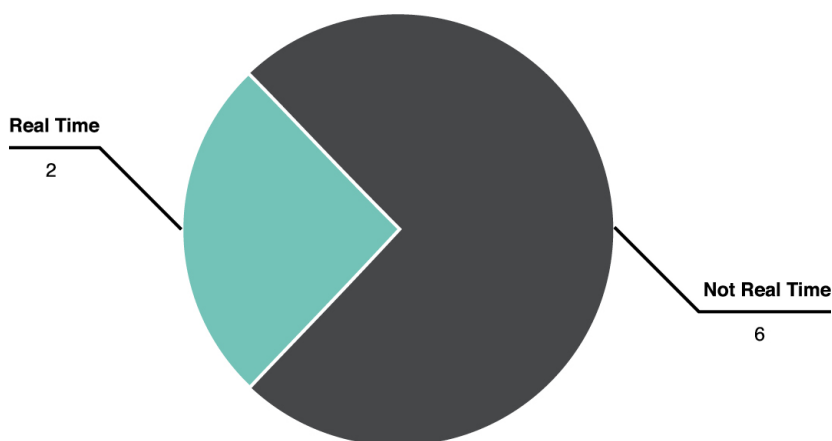


Figure 90 Data use

• Sound descriptors were used in the final work

The sound descriptors storage is a good way to make time representation of the sound however too much information can be hard to process or be useless for artistic use. Before this issue, the majority of the users decided to only deal with 3 to 6, of the 12 sound descriptors available, in the same piece, except for the creation of URB xy visualiser by the digital artist Diogo Tudela, described in subchapter 7.6 - URB XY, in which all the descriptors were used (Figure 91).

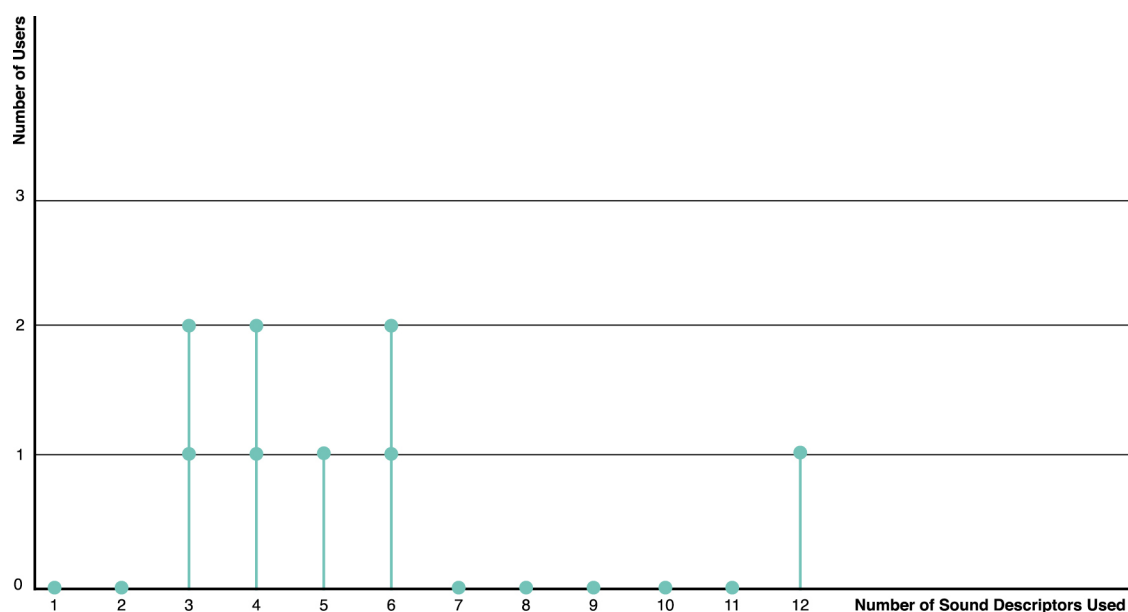


Figure 91 Number of sound descriptors used in each piece

• Number of listening points used in the final work

Before the possibility of using information from only one to four places in the city, the choices did not gather consensus, leading to a wide distribution among the different possibilities (Figure 92).

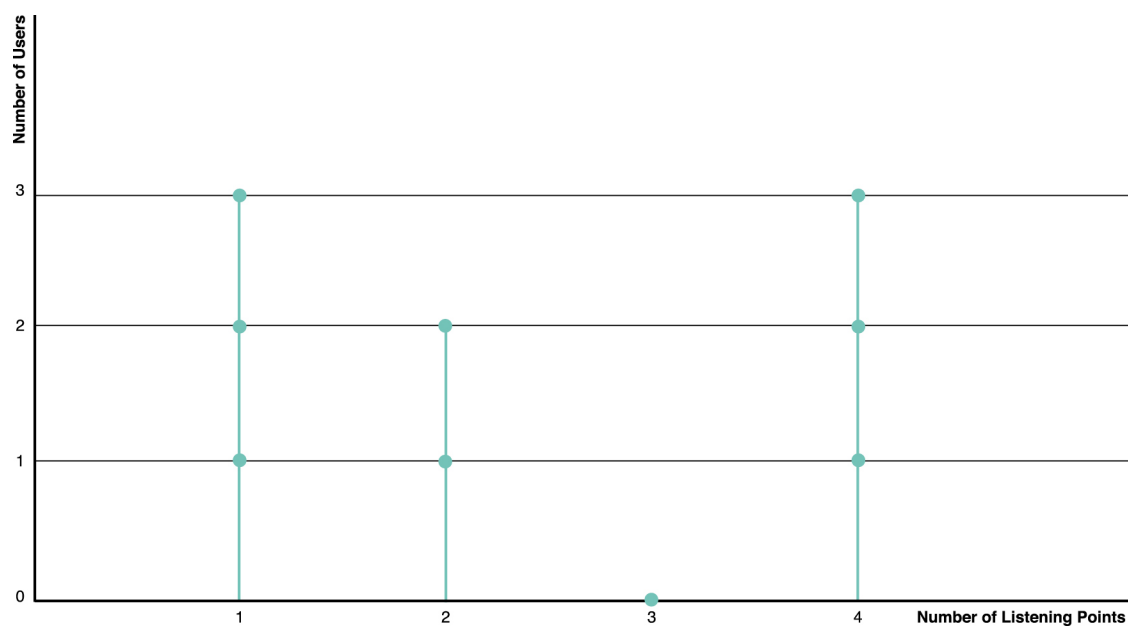


Figure 92 Number of listening points used in the final work

• Final work format

The most chosen formats were either installation or real-time performance. It is however possible to observe two other completely different approaches: one as classical instrument piece and the other as a software program. This demonstrates the system and the approach is versatile enough to be applied in different contexts (Figure 93).

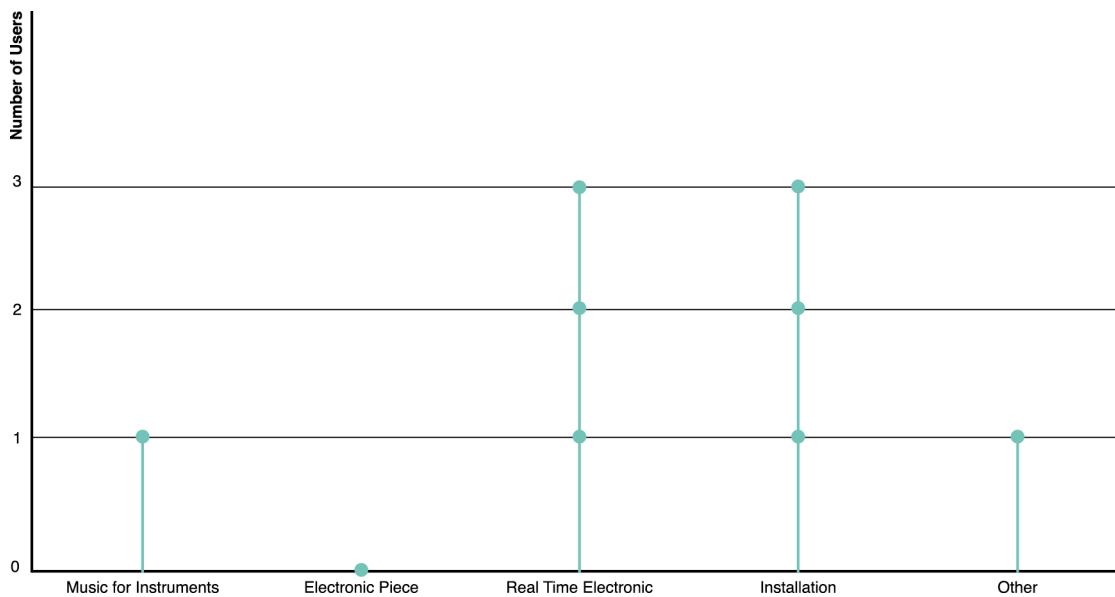


Figure 93 Final work format

• Soundscape sounds used in the final work

During the progress of our investigation a problem occurred: the data collected presented such a high level of abstraction that the need to use the original sound soundscapes, or similar contents, appeared easily, as a way of shortening the distance of the source and the final work in order to respect the soundscape composition principals. Nevertheless this pressure was not passed on to the artist, and we believe this was quite important to understand if they felt the same need, consciously or not. The results did not allow for a categorical conclusion, having verified exactly the same number who chose one or the other solution. Some artists feel the need to use real soundscapes in the final work, however is not universal (Figure 94).

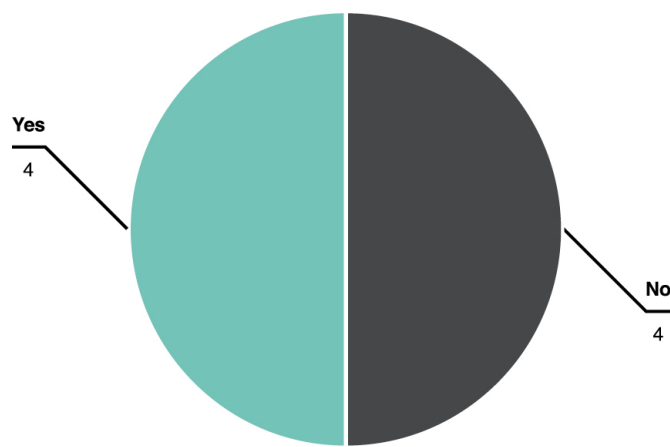


Figure 94 Soundscape sounds used in the final work

• **The degree of difficulty of the conceptual application of the data in the artistic environment**

In the first section of the questionnaire we study to what extent the artists felt technical difficulty in applying the data in their artistic processes. After concluding that this issue was not an obstacle, in this point we want to understand, technical processes aside, the level of conceptual difficulty that they felt in applying this data in their artistic exercises. The majority of the users did not feel major difficulties in this process, which leads us to conclude that the soundscape data could contain artist material, however this is not totally obvious or clear requiring some effort and preliminary experiments (Figure 95).

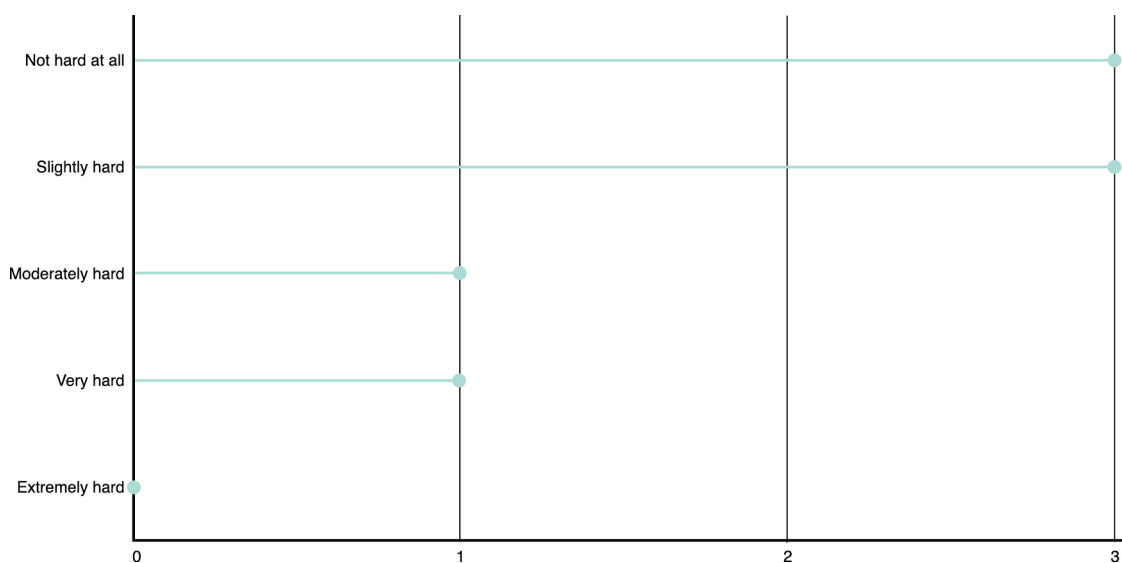


Figure 95 The difficulty degree of the conceptually application of the data in the artistic environment

• Artistic Expectations

In this question we wanted to understand to what degree the final work fulfilled the initial individual expectations before this approach. Although there are many personal factors that influence the response, this still helps judge the predictability, or unpredictability, of this data. None of the users felt their expectations dashed, however only one was totally fulfilled (Figure 96). As such this proves that the data is controllable to the point that it is possible to work with it while maintaining a slight level of unpredictability and abstraction.

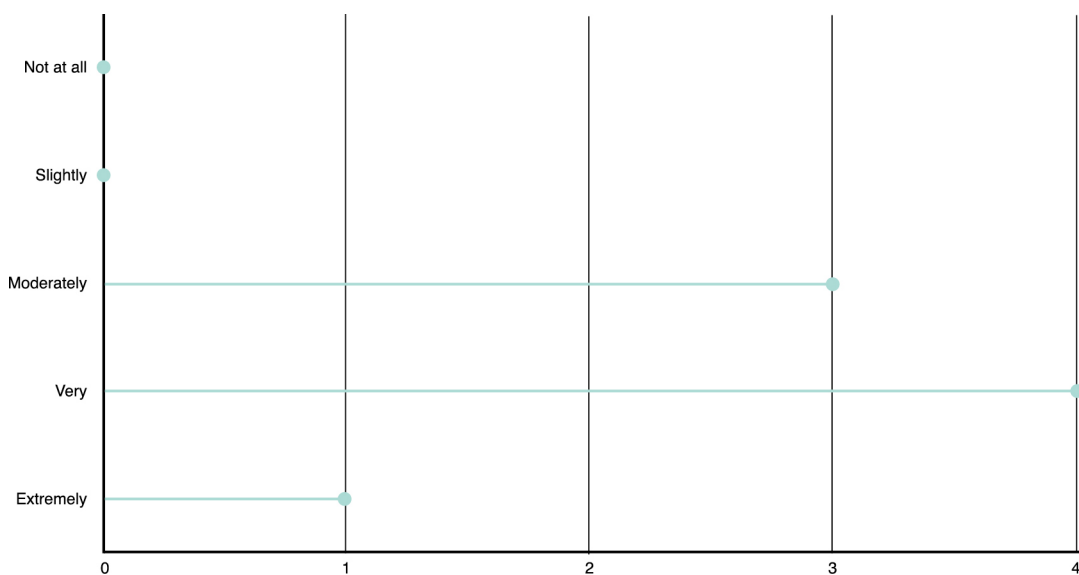


Figure 96 The degree to which the final work fulfilled the initial individual expectations

• The proximity between the original soundscape and the final work

This point is to understand if the fundamental principal of the soundscape composition is maintained or not, because for a given work to be considered a sound composition should have direct relations with the sound's original source, place, time, situation or context (Truax, 1994). The answer for this question is complex and the fact that we kept the proximity with the original soundscape undefined was intentional, leaving that interpretation to each artist. The moment that the data is used directly obtained from a soundscape, the Truax premise is technically fulfilled, however we wanted to hear the artists opinion if they felt that this is presented or not in the work itself. Although there are answers among the various possibilities, the majority of the artists felt that there is only a slight proximity between the final work and the original soundscape (Figure 97).

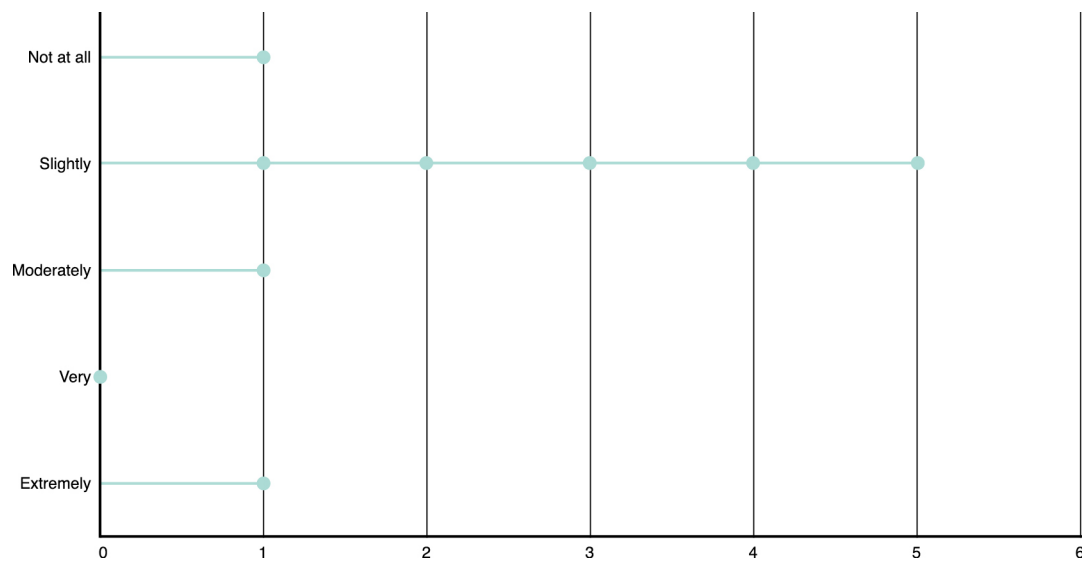


Figure 97 proximity between the original soundscape and the final work

• The artistic relevance of this approach

This last question on the questionnaire was the only one not using a Likert-scale answer; we asked to the artists to share their opinion in their own words. This is crucial to understanding the artistic validity of the project and to structure future options and goals.

All the users responded positively. The answer was not universal, it relies on how the composer relates to meta-data and of course, how a composer understands what “soundscape composition” is.

Some artists gave a positive evaluation based on the final work results, such as:

*The musical parameters extracted from URB are extremely useful in the definition of clear and coherent compositional material;
or this approach allowed for the emergence of sophisticated and rich textures and rhythmic patterns.*

Other artists made a deeper analysis focused on the compositional process pointing out the differences to other databases:

From a musical composition perspective, the idea of using any type of data as a control source and input to build a compositional system or real-time interactive system has always been very familiar to composers. I found the type of data obtained with the URB system particularly interesting, as it is the result of sound analysis, but also particularly challenging due mainly to the fact that it deals with a time scale which is not an audio rate representation of sound, but dispersed snapshots that represent the soundscape development over long periods.

The most interesting feedback for a future phase of the investigation is when the artist gave an evaluation based not on the processes but in the data itself and its relation to the final work. The slight lack of concrete recognition of data meaning in the final work was pointed out in as being an advantage:

The tool served as a counterpart to the art object, thereby providing details found in a subcutaneous level of the work. This level doesn't require a relation or recognition to the source by the listener, which is one of the objectives for the production of the work and principles that interested me in using the tool, in other words: non-recognition or the requirement of this, but a source material which provides a level that is comparable to any musical archetype. So it becomes a tool that provides a solid base for the development of a reservoir through various forms of reading data, allowing for the achievement of various results, similar to any other pre-existing music system;

Or being presented as a challenge:

My opinion is that URB is a magnificent technological tool, with clear practical uses for acoustic engineers, soundscape designers, sound ecology practitioners and, of course, people involved in sonification and visualisation. Using meta-data retrieved from soundscapes to create music, however, separates the compositional raw material from the sound itself. Looking at soundscape music composition history, this is not common. Actually it is on the opposite side of the spectrum if one adopts the approach of the WSP community. Nevertheless, this does not mean that URB is not useful for creating music. It certainly poses big challenges to composers that, like myself, are naturally inclined to use the concrete sounds themselves. The phenomenological connection between sound, creative process and composition becomes blurred, at least to my concern.

Chapter 9

Conclusions and Future Work

In this chapter we summarise the most significant contributions and outcomes of our research, during the course of the study are summarised.

According to the experimental nature of the project we never aspired to provide a yes-or-no answer or a specific formula able to solve the underlying mechanisms of the use of soundscapes in musical creation. Instead, we hope to contribute with a set of guidelines that we consider to be true and relevant when approaching soundscapes in the artistic creation context.

9.1 Summary Conclusion

Our initial goal was to contribute to the already well-developed and established Soundscapes community, both in the component for the capture and cataloguing of the sound environment, and in promoting a direct connection between that kind of approach to the sound environment and art creation.

The first conclusion to draw was that we were able to present a functional approach to the void indicated by Truax, that what's missing is a lack of temporal perspective in the usual sound maps that are based on a Google-style that focuses on the geographic origin of the recordings. After a good understanding of the theoretical and artistic background and preliminary research experiments we presented a prototype system, with a main focus on the time dimension, for capturing urban soundscapes. That system, called URB, is for automated analysis and storing based on available and inexpensive hardware and open source software. It complements the traditional sound maps, allowing the direct access of its features at any arbitrary moment since the system boot, thus facilitating the study of the soundscape evolution and the differences between specific timeframes. The data analysis results in 12 different elements or descriptors of the sound, four listening points in the city of Porto that are capturing and storing permanently, a free access database with all the information resulting from the capture, and free software to access the database. Implemented and tested by different users we conclude that URB is a stable and functional technological tool presenting a valid and pertinent approach, with clear practical uses for acoustic engineers, soundscape designers, sound ecology practitioners and people involved in sonification and visualisation.

The second conclusion stems from the first. After a preliminary work where we conclude that the soundscapes can provide useful data for artistic creation, and that lead to URB's development. We promote a direct connection between that kind of approach to the artists. We also create a situation where different creators, apart from this investigation, apply this approach and system in original works and help us to conclude its pertinence. From that process alone we produced a small survey of artworks, which were submitted to public presentation. This group of works are available freely to the general public as final pieces and to the academic and general music enthusiasts as detailed descriptions and analysis of the creative processes. Concluding about the absolute aesthetics pertinence

of a creative process is an impossible task to achieve and probably not the most important for a thesis of this nature. That conclusion should be reached its natural environment during the usual artist/audience interaction. However, before the works were developed and the artists feedback gained, even not ignoring the different approaches and opinions, we can conclude that this approach seems to promote new and functional soundscape composition ideas, making URB a relevant resource to compose original soundscape based music. Also, through the pieces analysis, we could point out patterns of the technical and artistic choices on how to deal with information from soundscape data, both in deferred time and real-time.

During the process of this research, besides all the consequential documentation, we believe that we contributed to soundscape awareness. This was achieved through the public concerts and venues with the pieces. We realised this awareness increase, besides the academic community, in the following: the Future Places Festival 2013 dedicated a venue to present some music pieces and installation developed in this investigation's context; the blog Everyday Listening¹³³, highly acknowledged by the Sonic Art community with a worldwide range, dedicated an article to this project, Visualising Porto's Soundscape¹³⁴, or used URB as a comparison model to similar projects in the article Cities and Memory¹³⁵. While this examples are from communities which are already sensitive to this kind of subject, this Soundscape approach reached the general public when the Portuguese newspaper Público, one of the most important and respected in the country, dedicated a full page in the Sunday issue of the 27th of October, 2013, to this project with an article called O fluxo de som da cidade do Porto inspira obras de arte¹³⁶ (Porto's sound flow inspires artworks).

The major contributions are in the **Soundscape** and **Eco-composition** fields of knowledge. Meta-data retrieved either from the soundscape, such as the one URB provides, or any other source, like solar winds for example, is well-suited to sonification installations/performances but not in musical compositions. However we believe that our research benefits other areas. Our conclusions are relevant for the **Composition** and **Automatic Generated Music** areas in general, seeing as the musical processes and approaches presented are not exclusive to soundscape composition. From a musical composition perspective, using data as a control source and input to build a compositional system, or real-time interactive system, has always been very familiar to composers. Our work also maintains a close relationship with the **Data Sonification** and **Visualisation** interaction, although our approach to the data was to achieve an artistic goal, inevitably in certain projects the sonification and visualisation

¹³³ Everyday Listening, founded in 2009 by the current Apple sound designer Hugo Verweij, collects inspiring and remarkable sound art and creative sound design projects, installations, reviews of urban soundscapes, places, contemporary or experimental, mostly electronic music. (Accessed, 11 December, 2014)

¹³⁴ <http://www.everydaylistening.com/articles/2014/3/14/visualising-portos-soundscape.html> (Accessed, 15 March, 2014)

¹³⁵ <http://www.everydaylistening.com/articles/2014/7/28/cities-memory.html> (Accessed, 30 July, 2014)

¹³⁶ The full article can be found in Annex G or at <http://www.publico.pt/local-porto/jornal/o-fluxo-de-som-da-cidade-do-porto-inspira-obras-de-arte-27301176> (Accessed, 28 Oct, 2013)

are present. Our research contributes to the **Sound and Music Technology** field in general since most of the processes can be easily separated and applied to other contexts, both from the stage of the capture and analysis, as well as the section of data-processing procedures. For example, through our work to fit the Raspberry Pi of an ADC and to connect it with the Pd software, we contribute strongly to the **Microcomputer** and **DIY** communities, even if they are rather far from using this for the some purposes that we are.

9.2 Future Work

Future work is from both a practical and theoretical perspective.

9.2.1 Practical

The project system, listening points and database, will continue to run, and the same goes for the website. With that we are going to increase the quantity of soundscape analysis storage, which will allow for more relevant information about the soundscape evolution as well as allowing for new artistic approaches and perspectives.

Maintaining the website and all the inherent information available we hope to draw the attention of new individuals or collectives to implement new listening points and new artists.

A natural process will be to carefully monitor the technological evolution of the micro-computing and components. If in the near future we hope to replace the power source with a solar powered battery system and to develop a stable system to use a Wi-Fi network. We believe that with these simple upgrades we can greatly increase the potential locations to put the listening points.

Since we are working with soundscapes, although only with a data perspective, it will be interesting to find a way to overcome the obstacles to work also with the sound itself. The main constraints are the privacy issue, computation processing, and storage dimension. The microcomputers are upgrading so quickly that the processing power will not be a problem in a very near future. Storing 24 hours of sound everyday for an unlimited time will be an unsustainable task and is probably irrelevant. However, it is possible to develop some process to select what we want to store. We think that the future of this process will be to get a sample of a soundscape everyday at the same time or even to develop a way for the computer to store all the sound that is substantially different to the regular. These approaches obviously need reflection and work, and their purpose is to complement the work already done, and not to substitute it. The privacy issue is another kind of problem that needs a deeper reflection.

9.2.2 Theoretical

As we described earlier it is quite difficult to draw final conclusions about aesthetic approaches. During this research we promoted the proximity between the artists and the URB system. It is important to understand if after this first approach a spontaneous continuation from some artists happens. During this observation it is imperative to continue to register and publish these works and processes in order to create more solid conclusions. We also consider it important to share and spread this reflection to other researchers and cities, in order to achieve a wider view of the subject and to point towards new directions and perspectives.

In the near future part of our future goals will be fulfilled, since our research and the URB system become a part of the artistic and educational project Phonambient. This project was created by the cultural association Sonoscopia with several academic and artistic partners and received funding support from the Portuguese Government and Direção Geral das Artes (Directorate General of the Arts) through the Apoios Pontuais¹³⁷ program.

Phonambient¹³⁸

A project based on the documentation and artistic transformation of the contemporary sound heritage. It aims at recording and preserving all the sounds that define a city or region on a digital database, including soundscapes, specific sound sources, musical fragments, phonetics and phonology. Phonambient will be applied to several cities: Braga, Guarda, Tondela, Castelo Branco, Fundão and Abu Dhabi. Sharing knowledge and resources gathered in order to create a wider and universal database is also intended. The shared resources include software developed, field recording techniques, electro-acoustic composition techniques, web servers, programming, design and audio equipment. Providing theoretical and practical knowledge to a local community that will be responsible for the further development of the project will be developed in the different cities. The work produced by the local community will be presented in each city. It will contain not only the field recordings, but also the artistic reflections produced, in forms of electroacoustic compositions, sound installations or theoretical reflections about the sound identity of each region.

This project will have the support of several partners: NYU Abu Dhabi¹³⁹, Esart¹⁴⁰ (Superior School of Applied Arts)/Castelo Branco City Council, A Moagem /Fundão City Council, Casa da Música Educational Department¹⁴¹, Acert¹⁴² (Cultural Association), AuAuFeioMau - Braga, Faculdade de Engenharia do Porto¹⁴³ (Porto Faculty of Engineering) and TMG¹⁴⁴/Guarda City Council.

The participation of the URB in this academic and artistic projects and the implementation of these features in future instances of this study will definitely increase the validity of the results achieved.

¹³⁷ <http://www.dgartes.pt/apoiopontual2014/decisaofinal.pdf> (accessed, 18 Dec, 2014)

¹³⁸ www.phonambient.com and www.sonoscopia.pt/en/projects/phonambient (accessed, 18 Dec, 2014)

¹³⁹ www.nyuad.nyu.edu/en/

¹⁴⁰ www.ipcb.pt/ESART/

¹⁴¹ <http://www.casadamusica.com/en/>

¹⁴² www.acert.pt/

¹⁴³ http://sigarra.up.pt/feup/pt/web_page.inicial

¹⁴⁴ www.tmg.com.pt/

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Acronyms

ADC	Analog to Digital Converter
AI	Artificial intelligence
API	Application programming interface
ARC	Association for Real Change
BC	Before Christ
CITAR	Center for Science and Technology of the Arts
CNMAT	Center for New Music and Audio Technologies
CNRS	French National Centre for Scientific Research
COST	European Cooperation in Science and Technology
CRESSON	Centre for research on sonic space & urban environment
CRiSAP	Creative Research into Sound Arts Practice
CVS	Comma-separated values
dB	Decibels
DIY	Do it yourself
EHESS	École des Hautes Études en Sciences Sociales
EMI	Experimental Music Intelligence
ENSA	Art Schools of Aix en Bourges
ENST	École Nationale Supérieure des Télécommunications
ESAA	Art Schools of Aix en Provence
FEUP	Faculdade de Engenharia da Universidade do Porto
FFT	Fast Fourier Transform
GIS	Geographic Information Systems
GPS	Global Positioning System
HTML	HyperText Markup Language
ILLIAC	Illinois Automatic Computer
INESC TEC	Instituto de Engenharia de Sistemas e Computadores - Tecnologia e Ciência
IP	Internet Protocol
ISO	International Organization for Standardization
JVM	Java Virtual Machine
k-NN	k-nearest neighbour
KIBLA	Kulturno izobrazevalno društvo (Association for Culture and Education)
LAMES	Laboratoire méditerranéen de sociologie
LAMP	Linux, Apache, MySQL and P (one of several scripting languages: Perl, PHP or Python)
LCC	University of the Arts London -London College of Communication
MIDI	Musical Instrument Digital Interface
MIR	Music Information Retrieval
MySQL	MyStructured Query Language
NMSAT	Networked Music & Soundart Timeline
OS	Operating system
OSC	Open Sound Control

Pd	Pure Data
PHP	Hypertext Preprocessor
PoE	Power over Ethernet
RDMS	Relational database management system
RRD	round-robin database
SAIC	School of the Art Institute of Chicago
SMC	Sound & Music Computing
SPL	Sound pressure Level
SQL	Structured Query Language
STEIM	Studio for Electro-Instrumental Music
UCP	Universidade Católica Portuguesa
USB	Universal Serial Bus
UTC	Coordinated Universal Time
WSN	Wireless Sensor Networks

Appendixes

Appendix A

Antonomásia_O Porto – Padrões Sociais Invictos
Digital Support (DVD)

Appendix B

Snapshot - Som Urbano sob Fundo Branco
Digital Support (DVD)

Appendix C

ConcertoX
Paper and Digital Support (DVD)

Appendix D

L'arbre des songes
Digital Support (DVD)

Appendix E

URB Box
Digital Support (DVD)

Appendix F

URB app
Digital Support (DVD)

Appendix G

Questionnaire used in URB research
Paper and Digital Support (DVD)

Appendix C

Concerto X

(Soundscape Section)

Full Score

Concerto X
Soundscapes Section

José Alberto Gomes

Tape starts with score.
time has to be exact.
The use of metronome is recommended

♩ = 129

Flute

Oboe

Bass Clarinet

Bassoon

Horn in F

Trumpet in B♭

Trombone

Violin solo
(Zingaro)

ussão Solista
(uno Aroso)

Piano Solo
(dro Rebelo)

Violin I

Violin II

Viola

Cello

Double Bass

pp

Sul Tasto

pp

Sul Tasto

p

14

Fl. *pp* *mp* *p*

Ob.

B. Cl. *pp* *mp*

Bsn. *mp* *p* *mp*

Hn.

B♭ Tpt.

Tbn.

Zingaro

Aroso

Pno.

Vln. I

Vln. II

Vla.

Vc. *mp*

D.B. *pp* *mp* *mp* *p* *p*

Detailed description: This musical score page contains measures 14 through 18. The instrumentation includes Flute (Fl.), Oboe (Ob.), Bass Clarinet (B. Cl.), Bassoon (Bsn.), Horn (Hn.), B♭ Trumpet (B♭ Tpt.), Trombone (Tbn.), Zingaro (a vocal or solo instrument), Aroso (another solo instrument), Piano (Pno.), Violin I (Vln. I), Violin II (Vln. II), Viola (Vla.), Violoncello (Vc.), and Double Bass (D.B.). The key signature has one sharp (F#), and the time signature is 4/4. Dynamics are indicated by *pp* (pianissimo), *mp* (mezzo-piano), and *p* (piano). The Flute part begins in measure 14 with a *pp* dynamic, rising to *mp* by measure 15, and then *p* in measure 16. The Bass Clarinet and Bassoon also have dynamics in measures 14-16. The Double Bass part is active throughout, with dynamics *pp*, *mp*, and *p* marked. The Zingaro and Aroso parts are present but contain no notes in this section.

23

Fl.

Ob.

B. Cl.

Bsn.

Hn.

B♭ Tpt.

Tbn.

Zingaro

Aroso

Pno.

Vln. I

Vln. II

Vla.

Vc.

D.B.

p

mp

p

mp

p

mp

p

pp

mp

pp

mp

p

35

Fl. *mp* *p* *p* *mf* *mf* *p* *f* *p*

Ob. *p* *pp* *pp* *p* *pp*

B. Cl. *p* *f* *pp*

Bsn. *p* *p* *mf*

Hn.

B♭ Tpt.

Tbn.

Zingaro

Arosio

Pno.

Vln. I

Vln. II

Vla.

Vc. *p* *mf*

D.B. *p* *mf*

47

Fl.

Ob.

B. Cl.

Bsn.

Hn.

B♭ Tpt.

Tbn.

Zingaro

Arooso

Pno.

Vln. I

Vln. II

Vla.

Vcl.

D.B.

mf

p

mp

f

pp

mf

p

f

pp

mp

pp

mf

p

58

Fl. *mp* *mf* *p* *p*

Ob. *pp* *p* *mp* *pp* *f*

B. Cl.

Bsn.

Hn.

B♭ Tpt.

Tbn.

Zingaro

Aroso

Pno.

Vln. I

Vln. II

Vla.

Vc.

D.B. *mp* *f* *p* *pp* *mf* *f* *p*

71

Fl. *mf* *f* *p* *f* *pp* *p* *mp*

Ob. *p* *f* *pp* *p* *mp*

B. Cl. *p* *p* *f* *pp* *f* *pp* *mf* *mp*

Bsn. *p*

Hn. *p* *con sordina* *pp* *mp* *pp* *pp*

B♭ Tpt. *pp* *mp* *pp* *pp*

Tbn. *con sordina* *p* *pp* *mp* *p*

Zingaro

Aroso

Pno. *improvise gradually more forcefully and violently privileging notes shown in the rectangle.*

Vln. I

Vln. II

Vla. *senza vibrato*

Vc.

D.B.

83

Fl. *p* *p* *f* *pp* *mf* *mf*

Ob. *p* *p* *mf* *f* *pp* *mf* *p*

B. Cl. *p* *f* *pp* *mf* *mf*

Bsn. *mf* *p*

Hn. *mf* *mp*

B♭ Tpt. *con sordina* *mp* *p*

Tbn. *pp* *mp* *p* *p*

Zingaro

Aroso

Pno. *pp* *mp* *p* *mf* *mp*

Vln. I *senza vibrato*

Vln. II *pp*

Vla. *pp* *mp* *p* *mp*

Vc. *p* *mf*

D.B. *p* *mf* *mp*

Detailed description: This musical score page contains measures 83 through 86. The instrumentation includes Flute (Fl.), Oboe (Ob.), Bass Clarinet (B. Cl.), Bassoon (Bsn.), Horn (Hn.), B♭ Trumpet (B♭ Tpt.), Trombone (Tbn.), Zingaro (a vocal or solo line), Aroso (a vocal or solo line), Piano (Pno.), Violin I (Vln. I), Violin II (Vln. II), Viola (Vla.), Violoncello (Vc.), and Double Bass (D.B.). The score is written in treble and bass staves. Dynamics are indicated by letters: *p* (piano), *mp* (mezzo-piano), *f* (forte), *pp* (pianissimo), and *mf* (mezzo-forte). Performance instructions include *con sordina* (with mutes) for the B♭ Trumpet and *senza vibrato* (without vibrato) for Violin I. The piano part features complex chordal textures with some notes beamed together. The string section provides a harmonic foundation with various articulations.

93

Fl.

Ob.

B. Cl.

Bsn.

Hn.

B♭ Tpt.

Tbn.

Zingaro

Aroso

Pno.

Vln. I

Vln. II

Vla.

Vc.

D.B.

p *mf* *p* *mf* *p* *mf* *pp* *f* *pp* *f*

105

Fl. *pp* *f* *mp* *f*

Ob. *pp* *f* *mp* *f*

B. Cl. *pp* *f* *mp* *f*

Bsn. *pp* *f* *mp* *f*

Hn. *pp* *mf* *p* *pp*

B. Tpt. *mp* *mp* *p* *mf* *p* *pp*

Tbn. *mf* *mf*

Zingaro

Aroso

Pno.

Vln. I

Vln. II

Vla. *p* *mf*

Vc. *pp* *mf*

D.B. *mf* *pp* *fpp*

115

Fl. *mp* *ff* *mf* *mp*

Ob. *mp* *ff* *mf* *mp*

B. Cl. *mp* *ff* *mf* *mp*

Bsn. *mp* *ff* *mf* *mp*

Hn. *mp* *p* *mp* *p* *mf* *p*

B^b Tpt. *mp* *p* *mp*

Tbn. *p* *p* *mf* *mp*

Zingaro

Arosó

Pno. *8* *8*

Vln. I

Vln. II

Vla. *p* *mp*

Vc. *mf* *mp* *p* *f* *mp*

D.B. *f* *mf* *p* *mp* *f* *mp*

135

Fl.

Ob.

B. Cl.

Bsn.

Hn.

B♭ Tpt.

Tbn.

Zingaro

Aroso

Pno.

Vln. I

Vln. II

Vla.

Vc.

D.B.

f

p < f

p < f

mp

f

mf

f

mf

f

mf

p

mp

f

p

mp

mf

mf

mf

p *f*

145

Fl. *f* *mf* *f*

Ob. *f* *mf* *f*

B. Cl. *f* *mp* *mf*

Bsn. *f* *mp* *mf*

Hn. *p* *pp* *f* *mp*

B♭ Tpt.

Tbn. *pp* *f*

Zingaro

Arosio

Pno. *grace*

Vln. I

Vln. II

Vla.

Vc. *mf*

D.B. *f* *pp* *f*

153

Fl.

Ob.

B. Cl.

Bsn.

Hn.

B♭ Tpt.

Tbn.

Zingaro

Aroso

Pno.

Vln. I

Vln. II

Vla.

Vc.

D.B.

mf

f

p

mp

162

Fl. *p* *p* *f* *mp* *f* *ff* *f* *f* *f*

Ob. *p* *p* *f* *mp* *f* *ff* *f* *ff* *f*

B. Cl.

Bsn.

Hn. *mp* *p* *mp* *p* *mf* *p*

B^b Tpt. *p* *f*

Tbn. *p* *f*

Zingaro

Arosio

Pno. *ff*

Vln. I

Vln. II

Vla. *p* *mf* *p* *f*

Vc. *p* *mf*

D.B. *f* *mf* *f* *p* *mf*

171

Fl.

Ob.

B. Cl.

Bsn.

Hn.

B $\flat$ Tpt.

Tbn.

Zingaro

Arosó

Pno.

Vln. I

Vln. II

Vla.

Vc.

D.B.

mp

180

The musical score for measures 180-189 includes the following parts and markings:

- Fl.**: Measure 184 has a dynamic marking of *f*.
- Ob.**: No markings.
- B. Cl.**: Measure 184 has a dynamic marking of *p*; measure 185 has a dynamic marking of *f*.
- Bsn.**: Measure 184 has a dynamic marking of *f*; measure 185 has a dynamic marking of *pp*.
- Hn.**: Measure 180 has a dynamic marking of *f*; measure 181 has a dynamic marking of *p*; measure 182 has a dynamic marking of *f*; measure 183 has a dynamic marking of *mp*; measure 184 has a dynamic marking of *mf*; measure 185 has a dynamic marking of *p*; measure 186 has a dynamic marking of *mf*.
- Bs. Tpt.**: Measure 180 has a dynamic marking of *mf*; measure 181 has a dynamic marking of *mp*; measure 182 has a dynamic marking of *f*; measure 183 has a dynamic marking of *mf*; measure 184 has a dynamic marking of *p*; measure 185 has a dynamic marking of *mf*.
- Tbn.**: Measure 180 has a dynamic marking of *mf*; measure 181 has a dynamic marking of *p*; measure 182 has a dynamic marking of *f*.
- Zingaro**: No markings.
- Aroso**: No markings.
- Pno.**: Measure 180 has a dynamic marking of *8va* with a dashed line; measure 181 has a dynamic marking of *8va* with a dashed line; measure 182 has a dynamic marking of *8va* with a dashed line; measure 183 has a dynamic marking of *8va* with a dashed line; measure 184 has a dynamic marking of *8va* with a dashed line; measure 185 has a dynamic marking of *8va* with a dashed line; measure 186 has a dynamic marking of *8va* with a dashed line; measure 187 has a dynamic marking of *8va* with a dashed line; measure 188 has a dynamic marking of *8va* with a dashed line; measure 189 has a dynamic marking of *8va* with a dashed line.
- Vln. I**: Measure 180 has a dynamic marking of *mp*; measure 181 has a dynamic marking of *mf*; measure 182 has a dynamic marking of *p*; measure 183 has a dynamic marking of *mf*; measure 184 has a dynamic marking of *f*.
- Vln. II**: Measure 180 has a dynamic marking of *f*; measure 181 has a dynamic marking of *mp*; measure 182 has a dynamic marking of *mf*; measure 183 has a dynamic marking of *p*; measure 184 has a dynamic marking of *mf*; measure 185 has a dynamic marking of *f*.
- Vla.**: Measure 180 has a dynamic marking of *mp*; measure 181 has a dynamic marking of *mf*; measure 182 has a dynamic marking of *p*; measure 183 has a dynamic marking of *mf*; measure 184 has a dynamic marking of *f*.
- Vc.**: Measure 180 has a dynamic marking of *p*; measure 181 has a dynamic marking of *mf*; measure 182 has a dynamic marking of *p*; measure 183 has a dynamic marking of *mf*; measure 184 has a dynamic marking of *f*.
- D.B.**: Measure 180 has a dynamic marking of *p*; measure 181 has a dynamic marking of *mf*; measure 182 has a dynamic marking of *p*; measure 183 has a dynamic marking of *mf*; measure 184 has a dynamic marking of *f*.

190

Fl. *mf* *mp*

Ob.

B. Cl. *mf* *f* *pp* *ff*

Bsn.

Hn. *p* *f* *ff* *pp* *ff*

B^b Tpt. *mp*

Tbn. *pp* *f* *ff* *pp* *ff*

Zingaro

Arosó

Pno.

Vln. I *pp* *ff*

Vln. II *pp* *f* *pp* *ff*

Vla. *p* *f*

Vc. *f* *p* *mp*

D.B. *f* *mp* *pp* *f* *pp*

199

Fl.

Ob.

B. Cl.

Bsn.

Hn.

Bs Tpt.

Tbn.

Zingaro

Arosio

Pno.

Vln. I

Vln. II

Vla.

Vc.

D.B.

212

Fl.

Ob.

B. Cl.

Bsn.

Hn.

B♭ Tpt.

Tbn.

Zingaro

Aroso

Pno.

Vln. I

Vln. II

Vla.

Vc.

D.B.

Improvise gradually more strongly until climax
View document with notes

225

Fl.

Ob.

B. Cl.

Bsn.

Hn.

B♭ Tpt.

Tbn.

Zingaro

Arosó

Pno.

Vln. I

Vln. II

Vla.

Vc.

D.B.

p *pp* *p* *p < mp* *p* *f*

p *mp* *p* *f*

p *f*

p *pp* *p* *mf* *mp* *p* *f* *mf*

p *pp* *mf* *mp* *p* *f*

237

Fl.

Ob.

B. Cl.

Bsn.

Hn.

B $\flat$ Tpt.

Tbn.

Zingaro

Aroso

Pno.

Vln. I

Vln. II

Vla.

Vc.

D.B.

p *mf* *mp* *p* *mp* *p* *pp* *pp* *pp*

243

Fl.

Ob.

B. Cl.

Bsn.

Hn.

B♭ Tpt.

Tbn.

Zingaro

Arosio

Pno.

Vln. I

Vln. II

Vla.

Vc.

D.B.

f

p

mp

f

p

mp

f

pp

mp

improvise gradually more strongly until climax
View document with mp3s

End of improvisation

254

Fl.

Ob.

B. Cl.

Bsn.

Hn.

B♭ Tpt.

Tbn.

Zingaro

Aroso

Pno.

Vln. I

Vln. II

Vla.

Vc.

D.B.

266

Fl. 9 10 26

Ob. 9 10 26

B. Cl. 9 10 26

Bsn. 9 10 26

Hn. 9 10 26

B♭ Tpt. 9 10 26

Tbn. 9 10 26

Zingaro 9 10 26 End of improvisation

Aroso 9 10 26 End of improvisation

Pno. 9 10 26

Vln. I 9 10 26

Vln. II 9 10 26

Vla. 9 10 26

Vc. 9 10 26

D.B. 9 10 26

Concerto X

Motifs for improvisation part of Section B II (soundscapes)

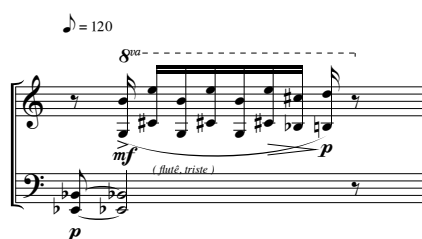
The motifs were taken freely from the O. Messiaen's *Catalogue d'oiseaux – XIII. Le courlis cendré*.

Execution:

The motifs below are just a starting point for improvisation accompanied by audio track pre recorded. There is no imposition of instrumentation or octave. Can and should be changed, repeated, varied, processed, etc.

The improvisation should be like birds dialogue / dispute between the two musicians, starting quietly and increasing tension and dynamic untill the climax.

I



II



III



IV.



V.



VI.



VII.



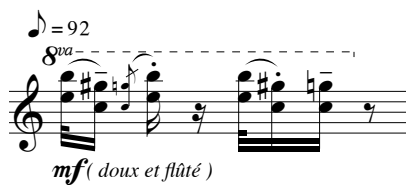
VIII.



IX.



X.



XI.



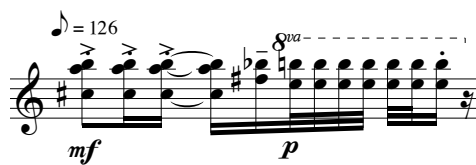
XII.



XIII.



XIV.



XV.



Appendix G

Questionnaire used
in URB research



Composing with Soundscapes: Capturing and Analysing Urban Audio for a Raw Data Musical Interpretation

This survey is part of a research project on topic Composing with Soundscapes: Capturing and Analysing Urban Audio for a Raw Data Musical Interpretation. It is intended for all who used the URB system (www.urb.pt.vu). There is no right or wrong answers. All data is confidential and will be used for scientific purposes only.

Identification

Name :

Age:

Artistic Background:

Please answer based on your opinion regarding your experience :

1. What was the difficulty degree in the accessibility and consultation of the database?

Extremely hard • Very hard • Moderately hard • Slightly hard • Not hard at all

2. What was the difficulty degree of the technical application of the data in the creation of the work?

Extremely hard • Very hard • Moderately hard • Slightly hard • Not at all

3. Which tool was used to access the database?

URBapp • URBapp changed • original Max patch • Database directly (via browser) • Other

4. How was the data used?

Real time • Not real time

5. How many sound descriptors were used in the final work?

6. How many listening points were used for the final work ?

7. What is the format of the final work?

Musical piece for instruments • Electronic piece • electronic piece performed in real time • Installation • Other

8. Did you use soundscape sounds in the final work?

Yes • Not

2. What was the easiness degree of the conceptually application of the data in the artistic environment?

Extremely hard • Very hard • Moderately hard • Slightly hard • Not at all

9. Before this approach, in what degree the final work fulfilled the initial expectations?

Extremely • Very • Moderately • Slightly • Not at all

10. What is the degree of proximity between the original and final work soundscape used?

Extremely • Very • Moderately • Slightly • Not at all

11. Is the artistic result of this approach relevant? Why?

Thank you!

Annex

Annex A

URB_to_B

Paper and Digital Support (DVD)

Annex B

Rascunho

Digital Support (DVD)

Annex C

(25-04-2013)x2

Digital Support (DVD)

Annex D

URB – We the Citizens

Digital Support (DVD)

Annex E

URB XY

Digital Support (DVD)

Annex F

Re-Interpretação Urbana

Digital Support (DVD)

Annex G

O fluxo de som da cidade do Porto inspira obras de arte article

Paper and Digital Support (DVD)

Annex A

...URB to B...

Full Score

Nuno Peixoto

...URB to B...
duo de percussão
2013

Percussion I

Timpani

Bass Drum

Tam-tam

Wood-block

Lion Roar (or similar)

Percussion II

Cowbell

Wood-Block

Pedal Drum

Tom-tom

Snare drum

Tambourine

Triangle

Roto-tom low

Roto-tom Medium

Bongo low

Bongo medium

Multipercussion

+

Vibraphone (arco)

Xylophone

Antique Cymbals

Ca. 9 min.

[illegible]

[illegible]

E

$\text{♩} = 120$

69

R

f sempre

Atenção!!! a nota Ab (no timpano) é sempre "Rim shot"

E ON

(rim shot)

f sempre

E

$\text{♩} = 72$

movimento lento

(normal)

f

Multipercussion

Vib

mf

ff

86

E

improvisar (não constante)

pp

Timpani (cont.)

mp

(baqueta)

pp

mf

mp

Antique Cymbals

Vib

p

* $\Omega\Omega\Omega$

[illegible]

8

Annex G

O fluxo de som da
cidade do Porto inspira
obras de arte article

PÚBLICO, DOM 27 OUT 2013 | LOCAL | 21

O fluxo de som da cidade do Porto inspira obras de arte

Projecto Urb tem quatro pontos de escuta espalhados pela cidade, a registar as características do som. A partir delas será feita arte no festival FuturePlaces, que começa amanhã

Festival
Pedro Rios

José Alberto Gomes fez o teste. Os candeeiros junto à sua casa acendem-se à noite, sempre à mesma hora, e emitem um som a que corresponde uma nota: o ré sustentado. A partir dessa nota, José construiu uma peça musical, que reúne também outros dados que caracterizam sonoramente um dia naquele lugar. De onde vêm os dados? Do sistema Urb, que o músico montou e cujos dados disponibiliza na Internet.

Recuemos a Maio. Nesse mês, este doutorando da Universidade Católica do Porto, com 30 anos, instalou o primeiro ponto de escuta, na Rua de Sá da Bandeira, junto ao Mercado do Bolhão. Desde então, colocou mais três, na esquina das ruas Oliveira Monteiro e da Boavista, na esplanada da Casa da Música e na Praça do Exército Libertador (Carvalhido).

Nestes quatro pontos, os microfones e computadores baratos instalados por José Alberto Gomes não gravam o som das 24 horas de um dia, mas registam, ininterruptamente, as suas características (se é alto ou baixo, agudo ou grave, entre muitas outras).

José não quis fazer mais um dos muitos mapas sonoros que existem no mundo - e também no Porto. "O que é um som representativo do Porto? É que em Janeiro o som é diferente do de Agosto. E na Boavista é diferente do do Parque da Cidade. Os *sound maps* dão uma informação mais completa [porque dão a ouvir sons gravados], mas falham na questão da temporalidade", diz ao PÚBLICO.

"Não sabemos como era o som [do Porto] há 50 anos", refere. No futuro, poderemos saber como era o som da cidade em 2013 e nos próximos anos, se o projecto, em que todos os dados são de acesso livre (em <http://urb.pt/vu>), crescer. "Precisava de ter muitos pontos distribuídos pela cidade. Espero que aconteça. É um projecto aberto, que se pode tornar comunitário." Com o Urb, espera, as comunidades científica e ambientalista terão mais uma ferramenta para estudar "a evolução sonora" da cidade.

Ao contrário da poluição visual, a sonora pode passar despercebida, mas "tem efeitos". Através das características que o Urb regista, especialistas podem corrigir situa-



José Alberto Gomes regista as características do som, 24 horas por dia, em quatro pontos da cidade

FuturePlaces é um medialab

"Não tem audiência, tem participantes"

Éra um festival, agora é um medialab. O Future Places (FP), que decorre de amanhã a sábado, reforça a sua vocação de laboratório sobre a questão de como os "media podem contribuir para a regeneração social e cultural", diz o coordenador Heitor Alves. "O nosso trabalho é contínuo, não é só uma semana. Temos gerado projectos que estão estabelecidos." É o caso da comunidade musical do centro comercial Stop e da Rádio Manobras. A decorrer em vários lugares do Porto, o



FP, iniciativa da Universidade do Porto no âmbito do Programa UT Austin-Portugal, conta, entre outros, com o realizador e actor Bruce Geduldig, o músico Andrew Poppy e a documentarista Debbie Anzalone e José Alberto Gomes (foto). Mas, diz Alves, o nome mais forte do cartaz "é o dos cidadãos", que podem participar nos vários *citizen labs*. "O medialab não tem audiência, tem participantes."

ções literalmente invisíveis. Mesmo um som com poucos decibéis pode ser perturbante, se for "constante ao longo do dia", por exemplo. É o caso dos sistemas de ar condicionado: "Vivia ao lado de um hospital militar e era tramado. Não era forte, mas tinha um espectro muito grande e esava sempre ali."

O som do 25 de Abril

O potencial interesse científico e ecológico do Urb é um bônus, já que José Alberto Gomes fez o projecto a pensar na sua tese de doutoramento na Escola das Artes da Católica, que está na fase final. "Sempre me interessou a relação entre o ambiente sonoro e a arte", diz. "Pode haver uma relação directa entre a criação e o som?"

Decidido a responder à questão, feito com sucesso o teste com os candeeiros da sua casa, convidou amigos para produzirem obras de arte a par-

tir da imensidão de dados que o Urb recolheu e recolhe. A apresentação é quarta-feira, às 22h, na Associação Sonoscopia, no Porto, no espectáculo *We, the citizens*, integrado no FuturePlaces que começa amanhã.

A performance conta com criadores da música electrónica, mas as possibilidades do Urb não se ficam pela criação musical: Gustavo Costa e Eduardo Magalhães apresentarão uma escultura com materiais, como chapas, que vibram conforme o som registado num outro ponto da cidade.

O duo de música electrónica Palmer Eldritch aceitou o "desafio ao mesmo tempo aliciante e complexo", diz Luís Fernandes, um dos membros. Trabalharam os volumes e os tons registados ao longo do dia 25 de Abril deste ano em Sá da Bandeira e no Carvalhido. A composição é gerada pelo computador de forma automática. "Nós moldamos o som."