Perceptualization machines: environmental data sonification based on electroacoustic music

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Introduction

Environmental data sonification has been an inspiring topic for new media artists [1] and other researchers interested in spreading relevant scientific information across the population [2]. While computer music tools are the main resource to acoustically display scientific data, Electroacoustic Music (EAM) analysis can also play an important roll by enriching, diversifying and extending the sonic content with which these systems deal. According to Supper, “...many sonifications stress that they regard sound as a way of allowing people to emotionally connect with something otherwise incomprehensible.” [3]. Perceptualization machines presented here bridge the gap between the empirical and scientific reading of reality, which are in constant negotiation in the definition and understanding of our surroundings. Particularly, by adopting an artistic approach to sonification, I am interested in questioning the roll of scientific data about air pollution in the everyday life of my local community and enhancing awareness to environmental conditions through a rewarding listening experience.

I will discuss Auditory Display (AD) and sonification strategies adopted in three perceptualization machines where air quality information is portrayed by sound: AirQ jacket [4], Esmog Data [5] and Breathe! Although being inspired by electroacoustic composition concepts and insights, these projects are not pieces of music, but objects and installations and can be also considered sound design and sound art works. They are the result of a two-years postdoctoral research about urban sound design conducted along with MA and PhD students of the Caldas University Design and Creation program in Manizales, Colombia.

We will also discuss sound creation from the perspective of Design studies, since they give reasonable emphasis to methodology and propose project-based directions in the creative process [6]. Design thinking considers both, the aesthetics and functional dimension involving modelling, interactive adjustment and re-design [3]. The sequence of three projects allowed us to achieve partial results and conclusions and adopt them as inputs in the next prototype. By testing different AD and sonifications the same information, we find an opportunity to reflect about the implications and potentialities of each communication design.

Sonification aesthetics and listening

In our research, we discriminate between AD, which covers all the topics exploring the auditory channel as a non-verbal information conveyor, including the display
environment design (the audio system, speakers, listening facilities, etc...); and
sonification, the data-dependent generation of sound [7]. Although these studies
are mainly informed by psychological and physiological studies, they occasionally
takes into account sound design and music composition considerations. From an
aesthetic perspective, the goal of sonification would be producing “…auditory
representations that give insight into the data or realities they represent to enable
inference and meaning making to take place”. [8]. In this concern, EAM proposes
significant contributions to sonification studies by providing listening and
structuring models [9], [10], [11] which informs some listening frameworks that
are being currently discussed by AD scholars [12], [13].

Sonification listening explores the Schaefferian notion of Comprendre, which is
both, objective and abstract [14]. This fourth listening mode or function comprises
“…symbolic (i.e. consensual) relations between representamen and object” [15]
and is activated when facing a “…structure that has a sense and meaning for those
listeners who share the code” [9]. Sonification listening demands unequivocal
interpretations and potential actions in the case of alarms or notifications. In the
case of natural phenomena (astronomical, biological, genetic, environmental)
sonification can trigger a shift of mind related to the observed object, by unveiling
the relation between data and its reality. Furthermore, grounded by Kantian
aesthetics Supper [3] suggests that some artistic sonification pieces can lead to a
sublime listening, in which the sense of immensity and infinity arises in the
listener when the communication process let him/her witness a non-perceptible
natural phenomenon.

Air Quality data

Since the time dynamics of environmental data occurs in the course of hours or
days, input data is not assumed as compositional material. Instead, the sonification
machines aims to enhance environmental information by compositional resources,
and should be enjoyed as sound-augmented consulting devices. In our particular
context (Manizales, Colombia) the growing industry and vehicle fleet determines
important factors in the environmental contamination. In addition, an active
volcanic region regularly emanates toxic gases surrounds Manizales, and then air
pollution is now a critic element in the everyday life of local community. Although
there is significant available information about the topic, environmental data are
hardly taken into account by the community. From this point of view, air quality
data became a rich source of information to be interpreted and its sonification an
inspiring topic for those artists who aim to call attention about environmental
awareness. Moreover, It offers an opportunity to create auditory images relating
the surroundings, by triggering supplementary meanings to sound according to
encrypted information.

AirQ Jacket (2016)

The first project I will discuss is entitled AirQ Jacket. It is a wearable technology
garment with an attached electronic circuit, which measures contamination levels
and temperature and transforms this information to perceptual stimuli through
light and sound. It was created along with fashion designer Maria Paulina
Gutierrez whose participation in the laboratory triggered an interchange among electronic, sound and dressmaking crafting, which resulted in this unorthodox AD device.

Figure 1. The AirQ jacket sonification system runs in a custom-made, telephone-like sound artifact.

In the design process we reflected about the listening culture created around portability, which was promoted by the Walkman [16]. The AirQ wearer should be able to acoustically consult our AD device wherever he/she goes, in order to create healthy courses through the city. We also paid special attention to Johnatan Sterne study of XIX auditory devices [17], such as the stethoscope. In the medical field stethoscopic listening produces objectification, which is the “... capacity to make external and concrete, and hence situate as perceptually objective” [18]. Our wearable proposal included a custom-made artifact attached to the jacket that was built with a piezo-electric device located inside a plastic cabinet that totally kills the sound, unless you approach it the ear.

We faced a challenge when creating sonic content with the arduino microcontroller, since it allows a meager repertoire of sound generation possibilities. We opted to work with a couple of sound pulses of energetic attack sounds. The first one displays temperature by varying speed and contamination level by varying pitch. The second pulse acts as a grid of reference, a contextual sound [19] representing “normal” environmental conditions.

**Esmog Data (2016)**

Esmog Data represented both, an advance and a redirection in the research process. It is an immersive installation presented in the Art Exhibition of the 2016 Balance-Unbalance Festival [20] along with Christian Quintero and Vanessa Gañán. The piece displays through audio and motion graphics the temperature and the concentration of some toxic gases determining air quality index (CO, CO2, SO2 and PM10). The AD device comprises surround speaker system whose sonic content is constantly changing, since a custom-made environmental station located in the entrance of the exhibition space regularly refreshes the system.
While the discussion about prototyping was already reported, [21] we will focus here on the EAM criteria adopted in the sonification. The Esmog Data sonic material was produced with the Johan Eriksson EcoSYSTEM [22] pure data patch, since it offered a modular workflow of audio synthesis blocks in which sensor data can be input. Instead of mapping sensor data directly to single synth parameters (pitch, amplitude, rate, adsr), we associated each one of the sensor inputs to parameters in many synth blocks in the search of more complex intrinsic musical values. Dennis Smalley vocabulary [11] was helpful to establish the qualities of sound motion attached to each pollutant gas. NO2 was associated to the notion of unidirectional motion (ascent, plane, descent), PM10 to occupation of the spectral space (diffuseness-concentration), CO to textural growth process (agglomeration-dissipation), CO2 to multidirectional motion (exogeny-endogeny). Temperature was associated to the behavioral relationship of dominance-subordination among the toxic gases.

**Breathe! (2017)**

BREATHE! is our current sound art project and depicts the research findings. It is conceived as a multi-channel installation with no visuals, where the visitor should be able to identify each one of the measured toxic gases as a different sound source in the space. Since we are in the prototyping process we will discuss here some insights and motivations that have been introduced as variables in our project-based research.

The installation displays six human breathing sound loops, which shrink and stretch according to toxic levels, from different points in the space. The AD device provides a multisource environment in which the listener can walk through the exhibition space in order to approach to each speaker. An improved air monitoring station prototype located outdoors (with a more accurate CO2 sensor, a SO2 one and a Wi-Fi module) provides six different inputs attached to pure data wavetable samplers.
BREAT! deliberately intends to adopt a denotative strategy to sonification, by counting on the attraction of human gesture in the meaning making process as a strategy to call attention. The metaphor of the human breathing acts both, as a collateral effect of pollution and as a source of pollution information. Furthermore, it invokes the multimodal aspects of sound meaning by dealing with the tension and relaxation of muscles and activating a sort proprioceptive listening [9]. Another implication of dealing with this material is the emergence of emotional aspects of listening. The reference of the natural pulses of the human body being affected by contamination intends to pose a critical insight about human condition in a post-human society.

References
