

ATHSENSE: A MULTISENSORY OUTDOOR INSTALLATION

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ABSTRACT

The ATHSENSE installation is a four part AV installation based on environmental data from the city of Athens. It comprises four different installations: a visualization projection of the data, a sound installation where the data are being sonified, an installation comprising eight LED displays projecting texts from users of the web app of ATHSENSE, and a light installation reflecting the sound levels of a central point of Athens. The second of the four installations is presented here where data concerning CO, CO₂, humidity and others, together with texts provided by the web app users, are being sonified in a six-channel surround installation. In addition to the electronic sounds of the sonification, four kinetic sculptures are being triggered by the system which create acoustic sounds by hitting found objects. This installation is located at the Serafeio complex in Athens, and was commissioned to the Spatial Research Media Group by the municipality of Athens after their successful participation in the Interventions in the City competition.

1. INTRODUCTION

ATHSENSE is a four part sensory installation at a central point in the city of Athens. It is situated at the “Serafeio - Public building and digital art” and was commissioned to the Spatial Research Media Group [1] by the municipality of Athens in the context of the “Interventions in the City” project under the Polis2 pilot program [2]. The concept of the installation is to translate environmental data taken from a sensor station placed at the Serafeio complex that records temperature, luminosity, humidity, as well as noise level and atmospheric pollution (Carbon Monoxide CO and Dioxide CO₂, Benzene and solid particles) [3]. Associated with these data, is a web app [4] where users can provide information on how they feel about what they see, what they hear, what they smell, as well as a short general text about how they feel, thus act as human sensors.

The four installations include a visualization of the data projected on a wall adjacent to the entrance of the Serafeio complex, a six-channel surround sound sonification of the data combined with four kinetic sculptures situated next to the wall projection, an eight LED installation displaying the text of the web app users placed in the entrance of the conference hall, and a light installation repre-

senting the noise level derived from the sensor station placed on the ceiling of an outdoor kiosk. Here the second installation is presented. It sonifies the environmental data of the sensor station, excluding the noise levels, as well as the textual input provided by the users of the web app to express how they feel as a result of the environment they are situated in.

The intention of the sonification installation was to create an abstract environment inspired by the data of the sensors and not to provide a clear representation of this data through sound. For example, the humidity levels were represented by a procedural rain sound created with oscillators and filters and the CO₂ levels were expressed with a procedural electricity sound. The sonification of the short texts is probably more accurate in that the text provided by users is directly translated into audible Morse code and displayed by the 6-channel audio system. Bearing in mind that Morse code is a very well known audio codification method, but at the same time few people can actually interpret and understand the meaning of it when they perceive it (e.g. the telecommunications company Nokia used the SMS Morse code for an SMS alert [5], a very familiar sound which most people are probably ignorant of its meaning), this approach gained an artistic dimension which we wanted to incorporate to the installation. A significant aspect of the work is also the spatialisation of the sonification result. ATHSENSE aimed at affording the audience an auditory environmental experience positioned in the space of the stoa of the Serafeio building. Figure 1 shows the installation space where four speakers and four kinetic sculptures are visible.

2. RELATED WORK

In the 1950s, John Cage rejected the conventional conception of composition in music, as an internal relation of parts within a coherent musical whole. Instead, he practiced music-making, writing and installation as a process more akin to the chance encounters and stimuli that impinge upon us in everyday life [6]. His understanding of composition was more directed towards an idea of choosing randomly from among a set of possible options. This could be seen as ‘a shift from art as object to art as process, from art as a “thing” to be addressed, to art as something which occurs in the encounter between the onlooker and a set of stimuli.’ Underlying the issue of spatializing music is the relationship between sound and space. Architecture is the art of composing space; music is the art of composing in time...the properties of space and time are inseparable..... ‘Space gives form and proportion; time supplies it with life and measure.’ [7]. During the 20th century, music has undergone a series of emancipations [7], regarding



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The Data Sonification Installation

Figure 1: A view of the data sonification installation of ATHsENSE. Four of the six speakers (white, mounted on the top part of the walls) and the four kinetic sculptures (embedded in the wooden boxes) are visible in this image. Photo by Dimitris Delinikolas.

the concepts of dissonance (as witnessed in the work of Schonberg), noise (Varèse), stochastic form (Xenakis) and non-intention (Cage). Since the 90s, many artists and architects (Marcos Novak, John Fraser, Char Davies, Stephen Perrella, Greg Lynn, Karl Chu, et al) have produced works, which either directly or indirectly challenge the boundaries of what is understood as designing space. Parallel to this, music has also been perceived based on its spatial attributes rather than its temporal ones within the context of sound art installations. Xenakis Polytopes creations are considered to be among the most important such early works [8].

Sound art installations combined with data sonification is a field with a wide range of practical examples. Paine [9] equipped reed pods with sensors in order to obtain wind speed, wind direction, temperature and solar radiation. He then used this data applying Inverse Fast Fourier Transform (IFFT) algorithms to produce sound. Another example utilizing the Fourier Transform is Sturm [10] who sonifies buoy data by feeding it to an Inverse Discrete Fourier Transform (IDFT). Leslie et. al [11] presents a quadrasonic sound installation where the visitors control the sound with their brain waves captured via EEG recorders. Lindborg [12] sonifies earthquake data in a public sound installation by projecting bell sounds into space according to the geographical position of earthquakes, where their pitch and harmonicity reflect the epicenter depth and magnitude. Çakmak et al. [13] sonifies super high frequency lightning by activating pink noise generators going through resonant filters, when specified colors are detected. Kikukawa [14] creates generative audio based on the positioning of wood blocks on sand in a box indoors recorded by a live camera. Beyls [15] sonifies wind data in a very similar fashion as in ATHsENSE. In contrast to the examples above, the audio installation WindChime collects wind data live through the web and sonifies them according to the strength of the winds when it exceeds a certain threshold.

Apart from installations, data sonification in musical/audio works can also be found in fixed media, like sound compositions. McGee et al. [16] produced two sound works by sonifying seismic data. King [17] sonified gun licensing background checks and self-report data on loneliness to create two piano pieces.

Data sonification is also employed in music and sound art of web and radio broadcasts. *I Hear NY4D* is an auditory display plat-

form where recordings from New York are combined with sound events corresponding to data feeds based on the listeners location [18]. Tweetsapes, created by Hermann et al. [19], is a project that sonifies Twitter data streams and broadcasts them on the radio. This project focuses on the number of followers of people tweeting, their longitude and their distance from a central point in Germany, in order to affect timbre, panning, and reverberation of the resulting sound. Another broadcasting project by Hermann et al is [20] which sonifies weather data, including temperature, humidity, rainfall, snowfall, wind speed and directions.

Finally, Coti K. and Charitos created the Statistical Harp [21]. In this installation a literary text is fed into the system in a non-linear manner. The flow of the text functions as a kind of "Morse code" trigger for a series of motors plucking wire ropes. These wire ropes play a multiple function in this installation: firstly, as structural elements, secondly as sound producing material and thirdly as visual elements. The structural role of the ropes is to support all input/output devices, including the multi-channel speaker system, which produces the spatialized auditory aspect of the experience. Additionally, the occurrence of the text's letters is statistically analyzed and the result of this analysis affects the pitch parameter in the processing of sounds, originally produced by the wire ropes and consequently transmitted by the speakers. The presence and movement of visitors within the installation environment is detected and used as another parameter affecting the manner in which the Statistical Harp transforms the flowing text into audio.

3. DATA SOURCE

As the name of the installation ATHsENSE suggests, the concept is to retrieve sensor data about the city of Athens. These data concern CO, CO₂, humidity, light, sound levels, solid particles, volatile organic compounds (VOC), and temperature. They are collected by a sensor station placed in the Serafeio complex, a central point of Athens, where the installation is also located. Being a four part installation, not all data are used in all parts of it. The sonification part utilizes most of this data, excluding the sound levels which are used in the fourth part of the installation, mapped to light intensity.

Additionally, ATHsENSE also consists of a web app where users can provide scaled values about their feelings on what they currently see, what they hear, and what they smell, plus a short text about how they feel in general. The sonification part of the installation utilizes this last section of short texts.

4. SYSTEM ARCHITECTURE

The system architecture of ATHsENSE can be described as consisting of two distinct subsystems. The main subsystem is a server which includes the sensor station. It runs all the code for communicating the sensor values to the rest of the system and for collecting the user generated data through the ATHsENSE web application. The four different installations can be thought of as the second subsystem. In this report only the sound installation subsystem is described.

The audio installation subsystem consists of a BeagleBone Black and a Bela CTAG cape which connects to the Internet via an Ethernet cable. An Arduino MEGA is connected to Bela via its General Purpose Input Output pins. The Bela makes HTTP requests to the server to retrieve the sensor values. It also creates

all the procedural audio which sonifies these values. The Arduino MEGA controls the four kinetic sculptures by moving stepper motors. The Bela is responsible for enabling and disabling the kinetic sculptures by sending high and low voltages to the Arduino, according to the sensor values and predefined thresholds. When these thresholds are crossed, the procedural audio stops and the kinetic sculptures start moving for a certain amount of time after which, the sculptures stop and the digital audio is restored. Figure 2 is a diagram of the entire system architecture of ATHsENSE.

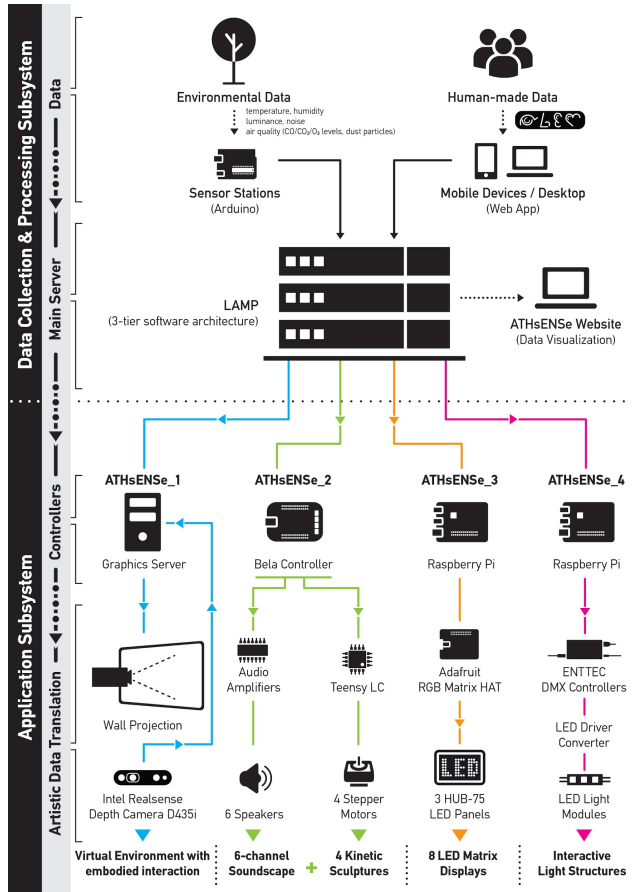


Figure 2: ATHsENSE system architecture diagram. Created by the Spatial Research Media Group.

5. SONIFICATION MAPPINGS

5.1. Procedural Audio

The procedural audio part of this installation was written in C++ utilizing the audio libraries provided by the Bela platform. The aim of the installation was not to sonify data in a straightforward manner, but to create an artistic soundscape which reflects the data of the system in an abstract way. Three different sound textures were used, each mapped to one data type. All sounds were procedural, either following a sound design paradigm, or were abstract sonic textures. Listing 1 shows a snapshot of the sensor values from the ATHsENSE server.

Listing 1

```
temperature:"29"
humidity:"43"
dust:"213"
co2:"33056"
voc:"38957"
co:"373"
light:"6578"
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(List of values used in the sound installation of ATHsENSE, as they appear on the project's server <https://server.athsense.gr/athsense-api/getdata.php>)

The CO2 values were mapped to the amplitude control of a procedural electricity sound, reflecting the use of carbon for the production of electrical energy. The humidity values were mapped to the amplitude control of a procedural rain sound. These two sound textures were inspired by the sound design examples of Andy Farnell [22]. The VOC values were mapped to the amplitude control of white noise passed through two band-pass filters with different center frequencies and equal Q values. The light values were mapped to the frequency of a Sine wave oscillator modulating the Q of the two band-pass filters. Solid particles (dust), CO, and temperature values were mapped to the spatial location of the electricity, rain, and filtered noise sounds respectively, in a six-speaker surround setup.

The mapping of these values works as follows. The server is updating its values every two minutes. Every time the Bela retrieves new values, it compares each value to its previous reading. If the value has increased a +1 is stored and if it had decreased a -1 is stored. This positive or negative 1 refers to the parameter of the sound each value is mapped to. For example, the CO2 value is mapped to the amplitude of the electricity sound. This sound is initialized with an amplitude of 0.5. If at the a reading of the sensor values the CO2 value has increased, the amplitude of this sound will increase by 0.1 and will be clipped at 1. If the CO2 value has decreased, the amplitude of the sound will be decreased by 0.1 and clipped at 0. The same applies to the amplitudes of all three sounds of the installation.

The surround sound panning of the sounds works in a similar way. Each sound has a sine wave controlling its position in the six-speaker setup of the installation. Each sine wave has one value of the ones provided by the server mapped to its frequency. The dust value controls the frequency of the sine wave which controls the positioning of the electricity sound, as mentioned above. Every time the dust value rises, the frequency of the sine wave increases by 0.01, and every time it falls, the frequency decreases by 0.01. These frequency values are clipped from 0.01 to 2.5 Hz.

Since the sensor values change very slowly over the course of a day, the overall sound of the installation is rather still. One can get two very different sounds though between two different times of the day. If for example one visits the installation at mid-day and then in the evening, both temperature and light sensors will give very different values, hence their corresponding sonic elements will be different.

5.2. Text and Morse Code

The short texts that were communicated by the users through the web app were expressed in audible Morse code. A 440Hz Sine

wave oscillator with short and long durations of a quarter of a second and a full second respectively was used for the dots and dashes of Morse code. For the sake of simplicity, only texts with the Latin alphabet were sonified with Morse code signals. Texts with the Greek alphabet were ignored by the system. The spatial positioning of the Morse coded text was controlled by a separate sine wave oscillator with a steady frequency.

5.3. Kinetic Sculptures

A second aspect of the sound installation piece of ATHsENSE was a set of four kinetic sculptures which produced non-amplified sounds by virtue of their movement and accompanied the six-channel surround sound system. These sculptures were assemblages of found objects, wooden elements and electronics (stepper motors, drivers etc.). The stepper motors, when triggered, mobilised a set of found objects, thus creating various rhythmic structures and adding another level of abstraction to the sonic result. The artistic intention underlying this aspect of the piece was to add a kinaesthetic aspect to the sonic experience perceived by the audience.

The overall set of the kinetic sculptures part of the sound installation was programmed in the Arduino language and controlled by an Arduino MEGA and stepper motors. The motors are triggered when the amplitude levels of the procedural sounds drop below a certain threshold, giving the impression of an acoustic element - contradicting the purely electronic one - which is correlated with less environmental pollution. Using one stepper motor for each sculpture each requiring one and a half amperes of current, the four sculptures require more power than the electronic sounds, hence a contradiction between environmental pollution drop and power consumption rise is created. This contradiction is augmented by the fact that the found objects, when hit by the motors, make louder sounds than the electronic ones due to a rather low volume set to the speakers. Figure 3 shows one of the four kinetic sculptures.



A Kinetic Sculpture

Figure 3: A kinetic sculpture from the sound installation of ATHsENSE including a motor with a found object fixed to the motor shaft. This functions as a lever which hits another found object which is a part of a fan cover. Photo by Dimitris Delinikolas.

6. CONCLUSIONS

The data sonification installation of the ATHsENSE four part installation has been described. This art installation aims to create a sonic environmental experience within which data are represented in an abstract rather than providing an accurate sonic representation. Although Morse code was used to translate text from the ATHsENSE web app to sound, the intention was not to let the visitors understand the actual text since most people are not aware of the meaning communicated by Morse code. Being one of four installations comprising the ATHsENSE project concept and realization, this installation aims to reinforce the overall experience of the visitors of the Serafeio complex rather than stand out as a single installation. Four kinetic sculptures accompany the six-channel surround sound system which when triggered hit found objects creating various rhythmic structures. This element adds another level of abstraction to the sonic result as, even though the resulting sounds of the sculptures are acoustic, the electrical current demands of the motors are higher than those of the electronic sounds. Additionally, the sounds produced when the stepper motors mobilise the found objects are louder than the electronic sounds.

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