"Urban Sounds": an acoustical tour of Parma

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Introduction

The urban landscape is constantly changing: habits and customs of the people, transportation, residential areas and industrial ones change themselves. From "visual" point of view, the number of media that allow us to keep track of the changes (photo and video) increases but it's not the same for the "acoustic" point of view. Almost all sounds and noises of an earlier eras have been lost. The idea behind this research, a collaboration between the Department of Industrial Engineering (University of Parma) and the municipal institution "Casa della Musica", is the sampling of the noise of the city, with state- of-art 3D audio recordings. The aim is dual: delivering to posterity an archive of recorded sound fields to document Parma in 2012 with advanced 3D surround recording techniques and creation of a "musical" Ambisonics composition for leading the audience through a virtual tour of the town.

Recording Equipment

The Microphone Array

The probe chosen for this research is the Eigenmike™ microphone array, produced by mhAcoustics [1]. As shown in Figure1, the Eigenmike™ is a sphere of aluminium (the radius is 42 mm) with 32 high quality capsules placed on its surface; microphones, pre-amplifiers and A/D converters are packed inside the sphere and all the signals are delivered to the audio interface through a digital CAT-6 cable, employing the A-net Ethernet-based protocol.

Figure 1: Eigenmike™, a 32 capsules spherical array.

The audio interface is an EMIB Firewire interface. It provides to the user two analogue headphones outputs, one ADAT output and the world clock ports for syncing with external hardware.

The probe is not equipped with a windshield, fundamental accessory for outdoor recordings, so we built an home-made one, taking care of leaving sufficient air around the sphere.

The Recorder

We used a Mac Book Pro 13" as recording machine, connected via firewire with the EMIB interface.

We chose Plogue Bidule [5] as recording software for having 48 kHz, 24 bit, 32 channels ".wav" files.

The gain of the probe was controlled by a custom Python application that generates a proper MIDI message and leads it to the Eignemike™.

The Places

Parma is a small ancient town, that finds its origins in the Roman era. During the ages the town was enriched with monuments, squares, parks, buildings that make this centre a destination for tourists from all over the world. For this reason was not simple to define the first relevant and characteristic places. We defined a first set of 30 locations, postponing to future recording sessions the many other places not sampled. In this set we sampled the train station, the airport, two public parks, several squares, a bridge, an highway, an outdoor market and some indoor public places as a commercial centre, a swimming pool, an underground parking, a school canteen and an Italian opera theatre.

For all these places a panoramic photo was taken in the same position of the microphone (an example in Figure 2).

Figure 2: example of a panoramic photo of "Piazza del Duomo", one of the most important squares of Parma.

The Virtual Tour of Parma

The Processing of the Recordings

All the collected recordings are 32-channels files, each channel containing the signal of the correspondent capsule. From such sampled sound field it is possible to derive any desired virtual microphone, shaping the polar pattern and pointing to any direction. The processing technique here used for deriving virtual microphones was developed by the RAI Research Center in Turin and by AIDA, a spinoff of the University of Parma [4]. We don't assume any theory for computing the filters: they are derived directly from a set of measurements. The characterization of the array is based on a matrix of measured anechoic impulse responses, obtained with the sound source placed at a large number D of positions all around the probe. A matrix of measured impulse response coefficients is formed and the matrix has to be numerically inverted (usually employing some approximate techniques, such as Least Squares plus regularization); in this way the outputs of the virtual microphone is maximally close to the ideal response prescribed. This method also inherently corrects for transducer deviations and acoustical artefacts (shielding, diffraction, reflection, etc.).

All the processing here summarized can be performed using a Matlab software, using as input data the number of desired virtual microphones, their polar patterns and their pointing direction. The output is a M x V FIR matrix, where M is the number of capsules (32) and V is the number of desired virtual microphones [3].

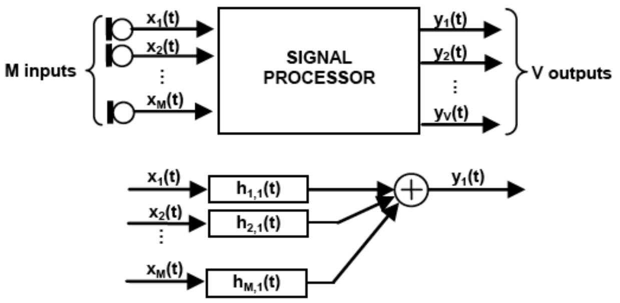

Figure 3: the scheme of the processing for deriving virtual microphones from an array of transducers.

In our case, the number of "virtual microphones" being synthesized is 16 because our goal is the conversion of our raw recordings to 3rd Order Ambisonics harmonics. Typically, each filter is 2048 samples long (at 48kHz sampling rate). Each harmonic, thus, requires to sum the results of the convolution of 32 input channels with "his" 16 FIR filters. And for getting all the required 16 Ambisonic outputs, we need to convolve-and-sum over a matrix of 32x16 FIR filters, each of 2048 samples.

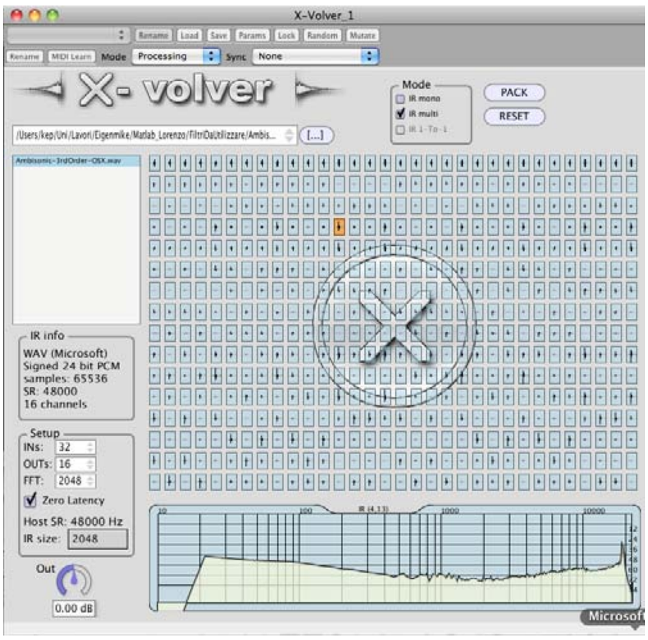

Figure 4: X-Volver and 32x16 matrix

For performing these massive multichannel filtering operations, a special VST plugin was developed, called X-volver, and running either on Mac or Win32 platforms; this plugin is freely available in [7]. Figure 4 shows the X-volver plugin being used inside Plogue Bidule [5], a multichannel VST host program: a 32x16 filter matrix is being employed for converting the signal coming form the 32-capsules spherical microphone array to the 16 3rd order Ambisonic signals.

A modern laptop, equipped with at least an Intel i5 processor, can easily perform such filtering in real-time, during the recording.

The Mix

The Virtual Tour is comparable to a musical composition: there are sounds that should be placed in a certain order, adjusted in level and mixed with the right timing. In this case all the mix was performed in a treated room (Figure 5) on Linux Ubuntu using the open source DAW "Ardour" [8] and Ambdec [9] for the decoding of the Ambisonic signals. The monitoring of the mix was performed by using a desktop pc with RME Hammerfall audio interface, Apogee AD-16x digital-to-analog converter, two QSC CX168 amplifiers and 16 Turbosound Impact 50 speakers. The speakers are placed on a regular octagon in the horizontal plane (3rd order), eight speakers are placed at +45° and -45° of elevation (1st order).

Figure 5: listening room in Casa della Musica (Parma).

Figure 6: the Virtual Tour of Parma is a route from S (train station) to E (airport).

The idea behind the mix is to lead the listener through a well-defined route (Figure 6), starting from the train station and ending to the airport of the town. The composition is accompanied by a "musical" soundscape, a common thread that binds all the urban soundscapes: this musical piece is the result of a recording session with Bloom, a interactive-generative iPad application developed by Brian Eno [10]. The sound coming from iPad is stereo but a special spatialization was performed for rendering the sound in Ambisonic format. Ardour, AMB-Plugins [9] and Zita-Rev [9] were used for achieving an engaging surround sound that was mixed to the recorded soundscapes.

The Listening Room

The Virtual Tour is available in a special Wave Field Synthesis room, named "Sala Bianca" (Figure 7), in "Casa del Suono" museum [11]. The "Sala Bianca" is designed for 30 seats (7.5 by 4.5m meters and 4.5m high) and equipped with 189 loudspeakers forming a complete crown around the room. These loudspeakers, not visible, are embedded in the walls, just above the ear's eight: the height of the ring is a compromise between typical ear height for a seated and a standing audience. This room employs a high number of loudspeakers, power amplifiers, D/A converters, all interfaced with state-of-art computers. The design of the audio system and control software was made by Fons Adriaensen [12].

The usable frequency range is 50Hz to 20kHz, and sound quality is remarkably good for a design of this size. Except for the space taken by the speakers the walls are completely covered by sound absorbing material, leading to reasonably good 'dead' acoustics.

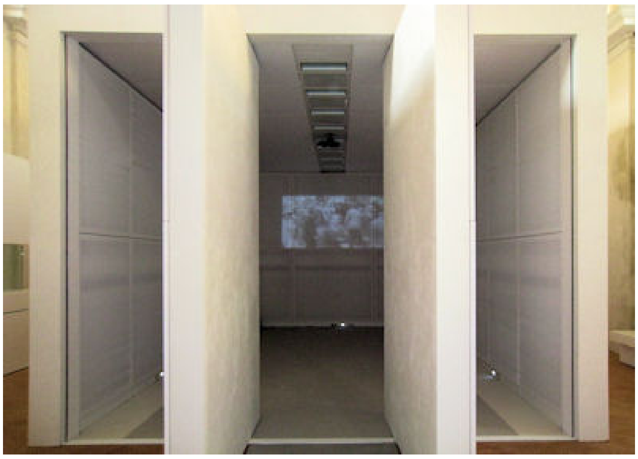

Figure 7: WFS room named "Sala Bianca", equipped with a 189 speakers ring.

In the case of this virtual tour, the Wave Field System is used for simulating eight "virtual" speakers placed on a regular octagon at a distance of 15 meters from the centre of the room. Such a distance is useful for loosing the perception of the proximity effect, leading to the listener plane waves. The reproduction of 3rd order Ambisonic compositions through a WFS simulation of the speakers ring gives better performances than a real ring. Unfortunately the system is a planar ring but the lack of speakers above the head is almost compensated by the detailed reconstruction of the sound field.

Conclusions

The goal of the "Urban Sounds" project was dual: the creation of an archive of 3D urban soundscapes recorded in Parma and the realization of an immersive virtual tour of the town performed in a WFS room. The composition, object of this paper, is actually available in "Casa del Suono" museum and the soundscapes archive is at disposal of artists and listeners. Everything concerned with the project is collected and displayed in the website www.urbansounds.info, in which the visitor could have a 10 seconds stereo preview of some of the soundscapes recorded.

The "Urban Sounds" project is at its first step but lot of work should be done:

- the number of the sampled places should be increased, covering other significant locations in Parma, in order to create a vast archive of urban soundscapes;
- the 3D recordings could be accompanied with a panoramic video, not only with a panoramic photo, for a complete immersive experience;
- the 3D recordings could be performed with different microphone probes, such as the 32 capsules cylindrical array actually in development at University of Parma;
- a permanent installation could be placed in the museum, giving to the visitors the choice of the town places in which they would like to be surrounded (the idea is a map of the town on a tablet that is used as a remote control).

Acknowledgements

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