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Spatiotemporal Recording in the Field

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ABSTRACT

A method for recording continuously, in motion without audible interference by the recording apparatus is proposed. The purpose of this method is the faithful reproduction of soundscapes as spatiotemporal continua without any audible traces of the recording procedure, i.e. transparently. This method is the result of an experimental plan to capture spatial variability of a sound field along with its temporal counterpart envisaging audio reproduction of field recordings as spatiotemporal entities. The sound recorded in this manner captures the finest details of the changes of soundscape due to its spatial variability that should be otherwise artificially calculated. For this purpose, the Moving Sound-Receptor (MSR) system was designed and tried in a variety of field recording situations. In this paper, we present an overview of this system and its use in field recording projects. Particularly, we examine its use in recording along vertical trajectories.

1. INTRODUCTION

For over a century and a half audio recording and reproduction technology has undergone continual progress. At all stages of this technological development, *fidelity* standards emerge expressing the similarity between original and reproduced sound in terms of technological criteria, i.e. measurable quantities, and by describing the "imagined psychological sense of realism" [1 p. 8], i.e. the subjective evaluation of the qualities of the reproduced sound as identical to the original [2 p. 215-286]. Such a 'realism' in audio recordings that aim to emulate "the illusion of relative motion between the listener and the auditory space" [3 p. 9] necessitates capturing simultaneously both the spatial and the temporal variations of the environmental sonic field. Recording audio using stationary audio capturing systems in combination with sampling methodologies can provide good approximations of spatiotemporal variations of environmental sonic fields within these areas [4]. While these approaches are sufficient for environmental research, particularly when the quality of the recorded audio is not a priority, they are insufficient for soundscape studies and virtual or augmented reality applications.

2. THE MSR

The Moving Sound-Receptor (MSR) is a system designed to conduct mobile recordings outdoors. Its development is based on the hypothesis that the mobility of the recording system, reassuring a continuous capturing of a sound field as it changes in time and in space, would lead to a very detailed, more verisimilar, reproduction of the soundscape as a spatiotemporal entity for someone listening while moving within the soundscape. In addition to recording in motion, recording transparently is an important aim in designing this system. To respond to these criteria, the MSR allows for mobile recordings along longitudinal trajectories, either horizontal or vertical without any sonic interference from its own operation. The MSR consists of a main component the *receptor* which carries the sound-capturing elements, i.e. the microphone and the audio recorder, and a support mechanism upon which the receptor moves between two steady boundary points. This system is described in [4].

3. The MSR Recordings

Maintaining compatibility with all sorts of projects the MSR produces recordings in many audio formats by means of Ambisonics. The microphone used in the MSR is a *Sennheiser Ambeo* together with the audio recorder *Sound Devices: Mix Pre 6*. The raw audio (96 kHz /24 Bit) from Ambeo in A-format is processed to FuMa B-Format using the software *Ambeo A-B Converter Plugin*. The audio can be rendered to binaural using the *JS ATK FOA Decode Binaural plug-in* using a HRTF (Head Related Transfer Function) corresponding to a middle size head, in order to be compatible with most listeners.

4. The MSR for Environmental Recordings

We have used the MSR for field recordings in motion. We present here two kinds of uses of this system: the first is a set of three recordings along horizontal linear paths and the second is a set of four recordings along vertical paths[1].

[1] All the recordings presented are formatted as mp3 - 320 kbps binaural audio archives; the use of headphones is recommended for full reproduction of three dimensional acoustic space.

4.1 Recording on a Horizontal route

The first tests of the MSR took place at Antinioti Lagoon, North Corfu, Greece, an area that was studied during a soundscape research project between 2005-6 [5, 6, 7, 8].

Two series of recordings were made. For both, the MSR is extended above a linear path between two trees at a distance of about 80 meters from each other (see Figure 1).

The first recording[2] was made with the *receptor* covering this distance, from one boundary position to the other, in 8 minutes and 23 seconds. The sound level in this place during the recording was quite low (LAeq = 27.5 dBspl). Listening the recording, the system records transparently except from some faint noise, which can be heard near the beginning and the end of the movement. The mobility of the recording system is not clearly understood because all sound sources (mostly animals) are far away and essentially spatially invariable along this - relatively - short linear transposition.

Figure 1. The horizontal MSR suspension.

In the second recording the *receptor* covered the same distance in reverse in 9 minutes and 38 seconds. This time however, in order to make the effect of moving along the path more pronounced, an artificial sound source – a wireless loudspeaker was placed 10 meters at the left side of this path in order to artificially alter the soundscape. The loudspeaker was playing back a recording of cicadas, recorded the previous summer. The biophony introduced deliberately into the field, was functioning as a distinct, stationary sonic presence. Placing however a sound source near the MSR's transposition path proved to be helpful to demonstrate the desired effect of moving along this path as it can be heard playing back the recording[3].

An additional intriguing soundscape was observed within the Antinoti lagoon. The process outlined in the method-ology of [5][6][7] was followed, resulting in a total of four recordings made over the course of a year around solstices and equinoxes. This shallow lagoon is an interesting ecosystem hosting a plethora of birds and small mammals - among which the endangered species of the otter (Lutra lutra). The MSR's receptor, securely attached to a small boat, was used to capture the sound field on the surface of the water as it changes along a linear slide of from 100 m to 150 m depends for the recording (see Figure 2). The recording presented here was realized on March 21, 2019 at noon and the small boat slides from 100 m. In the sound recording that has resulted from this experiment[4], two kinds of sonic ambiences can be distinguished at the two extreme positions of the boat, near the center and near the shore respectively. Geophonic and biophonic sounds dominate in the movement's beginning, in the middle of the lake, while as the boat moves toward the lake's shore, more and more anthropogenic sounds become audible. Following the spatial variability along the movement, the two soundscapes gradually transition from one to the other [9].

Figure 2. Recording on the Antinioti lagoon.

4.2 Recording along a vertical route

Two recording sessions using the MSR moving on vertical trajectories were realised. The first, parallel to the trunk of a tree, and the second ran parallel to one of the highest buildings in Athens (Greece).

The first recording along a vertical route was conducted on June 5, 2020, at Rematia situated in Halandri, a suburb of Athens (See figure 3). This particular site was chosen for its sonic diversity and for its tall aspen (Populus) and willow (Salix) trees (exceeding 30 meters in height) grown along the banks of a small ravine. The MSR was installed parallel to the trunk of a tree, using a branch at about 20 meters from the ground as a support, while the receptor was allowed to move along this vertical trajectory. The entire suspension mechanism of the MSR was modified in order to adapt to the needs of this type of transposition and to securely carry the receptor[5]. The spatiotemporal variation of the soundscape can be clearly heard in the audio recordings[6] even for this range of only 20 meters. The vertical movement of the *receptor* captures a continuum of

[2] These recordings can be accessed at: https://cutt.ly/DvABytk and https://cutt.ly/vbuZ98Q correspondingly.

[3] For more details about the recording area and extended analysis of the recordings see [4].

[4] This recording can be accessed at: https://cutt.ly/ibjpmVG. Also, a video documentation of this experiment can be accessed at: https://cutt.ly/Sbjp0RC.

[5] For more details, see [4]

[6] The linear upward motion and downward motion of the MSR recordings are accessible at https://cutt.ly/wbw544H and https://cutt.ly/CbeerKt correspondingly. An action camera mounted on the *receptor* parallel to the main-axis of the microphone has filmed the whole process and two video archives can be accesses at: https://cutt.ly/vbw6b4h (upward motion) and https://cutt.ly/xbewDS5 (downward motion) correspondingly.

slowly and imperceptibly changing soundscape as a successive crossfade of the sound layers corresponding to the various heights between the lowest and the highest points of this vertical trajectory. A correlation between the *receptor's* vertical motion speed and the soundscape's character alteration rate can be also observed. Near the ground, biophony dominates the soundscape yielding to anthropophony at higher positions because of the impact of the urban sounds (mainly traffic)[7].

Figure 3. Recording on vertical route at Rematia creek.

One more series of recordings in motion along a vertical path were realised on April 12, 2022 in the center of Athens. The MSR was mounted on the 19th floor of "Tower Apollon", the second highest building in the urban center of Athens. The recordings capture the sound while the MSR moves from the ground level up to 60 meters above the ground and vice versa. The spatiotemporal variation of the soundscape as it changes along this trajectory is presented in the audio recordings[8].

Figure 4. Recording on vertical route at Tower Apollon.

The differences between the soundscapes at the various altitudes along the vertical trajectory are easily distinguishable. This is due to a) the proximity to traffic and other anthropogenic sounds near the ground and a few meters above it, and b) the reflected acoustic energy, caused by the surrounding buildings, at the level of the ground and up to approximately the middle of the vertical trajectory (i.e., the tallest surrounding buildings' height).

5. CONCLUSIONS

The MSR was designed to record as accurately as possible spatio-temporal variations within a sonic environment as it can be perceived by a moving observer, maintaining the audio capturing process free from sonic interferences produced by the movement of the system itself. It is an ongoing project which at its current state of development can record while moving on linear paths at maximum 80 meters horizontally and 60 meters vertically. The quality of the recordings is very high and it allows compatibility with many playback formats (mono, stereo, quadraphonic, 5.1, etc.). Additionally, recordings from the MSR are highly accurate and can be rendered to create three-dimensional sound reproductions, highlighting the sensation of movement within the original soundscape.

The MSR can be used for environmental research and education as well as in all sorts of augmented and virtual reality applications to reproduce virtual soundwalks. It can also be used to record over trajectories non accessible to walkers. This method of recording is potentially useful in bioacoustic research because it can provide accurate representations of spatial variability of sonic fields. This accuracy becomes even more useful for vertical recordings where in forested landscapes "sound propagation is strongly affected by ground effect, by scattering from tree trunks and branches, and by absorption by leaves" [11 p.39] or, in the case of urban environments, by reflective surfaces from buildings and the distance from, often noisy, roads. Being able to reproduce spatiotemporal sonic variations, particularly as they appear in vertical movements, which is impossible to be experienced physically, can be useful for projects focusing on raising environmental awareness regarding sonic pollution, especially in urban areas.

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