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VIRTUAL ACOUSTICS IN SOUNDSCAPE ANALYSIS

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Abstract
Article shows a potential of virtual acoustic environment in Soundscape analysis. Study cases of natural and urban soundscapes are shown. Ambisonic and alternative techniques in soundscape conservation are considered with different arrangements and setups. The main goal of this work is to investigate what are the main features of listening environment that allows immersion and high fidelity of sound field. Article shows results of an experiment that validate factors that influences immersion, such as loudness and spatial distribution in soundscape virtual acoustics.

Keywords: soundscape, auralization, ambisonics

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1 Introduction

The soundscapes are associated with both social functions and time-spatial changes, or the places of residence. Social scientists, particularly anthropologists, emphasize the variety and forms of spatial arrangement of sounds and effects of soundscapes. The development of the area of studies on soundscapes indicates the possibility of creating a multi-sensory anthropology and sociology. The term 'soundscape' is well defined [1,2,3,4]. At the time being, wide-ranged research concerning its analysis and preservation is being carried out. The term 'natural soundscape' is, according to [5], an 'inherent acoustical environment of an area without the presence of human-caused sound".
For the purpose of soundscapes research and conservation one of the possibilities of research is virtual acoustics. The advantages of such method is obvious, for example, the possibility of research without the necessity of analyzing the dependant variables as atmospheric conditions etc. It is due to the repeatability and total control over the stimulus.
On the other hand, laboratory conditions are always approximations of reality. Research in situ as "soundwalk" type and other, gives the possibility to research soundscape without any compromise, by direct studies of the stimuli. Article [6] in which the problem of soundscape research by virtual acoustics method is taken, is the point of reference for this thesis. In the experiment stereo phase technique and 1st order ambisonics are employed. Detailed research over the impact of the sound recording and playback technique in soundscape studies can be found am. oth. in [7],[8]. Studies on the quality of reproduction of the sound field are carried out by different methods, mostly with the analysis of the physical sound field similarity [9], [10]. Some of the works is also considering the psychoacoustic properties mapping [11,12], which seems to be more appropriate approach for soundscape research. The key question is to determine what quality mapping is adequate and sufficient for the study of soundscape. This article attempts to verify what is the difference in perception of changes in spatial signal distribution

and sound pressure levels changes, so the most important changes from perception point of view. The aim of the study is to draw attention to the importance of the problem of the quality of representation of the acoustic field in the research of soundscape and a quantitative assessment of this quality.

2 Research methodology

The main goal of the experiment is to examine the influence of many spatial distribution of the signal variants in relation to acoustic pressure changes. For this purposes recordings of natural and urban soundscapes were made. Afterwards the sound samples variants were prepared. Those samples diversified in terms of spatial playback. The next step was the preparation of a psychoacoustic experiment to obtain evaluation for the samples used in the research.

2.1 Soundscape recording

The recordings were performed in two separate areas: Białowieża Forest and in Cracov. Bialowieża Forest has been designated a UNESCO World Heritage Site, a UNESCO Biosphere Reserve, and an EU Natura 2000 Special Area of Conservation (figure 1). The oldest forest in Europe preserved in its virtually natural condition. The recording and measurements were performed at selected characteristic locations at which the level of the acoustic background was registered at favourable weather conditions. The research of Białowieża Forests with detailed analyse of low level sounds, based on those recordings has been already started [13].

Figure 1 Exemplary photograph from the recordings and geographical location of Białowieża Forest

Recordings of Urban soundscape of Cracov city were also performed. Cracov is a historical city with medieval main square and many unique features. For the research purposes, the recordings were performer in university district, near busy avenue, bus stop, bicycle Road and a fountain. The exact location is show on figure 2. The recordings were performed while fountain was working and during the brake between the cycles.

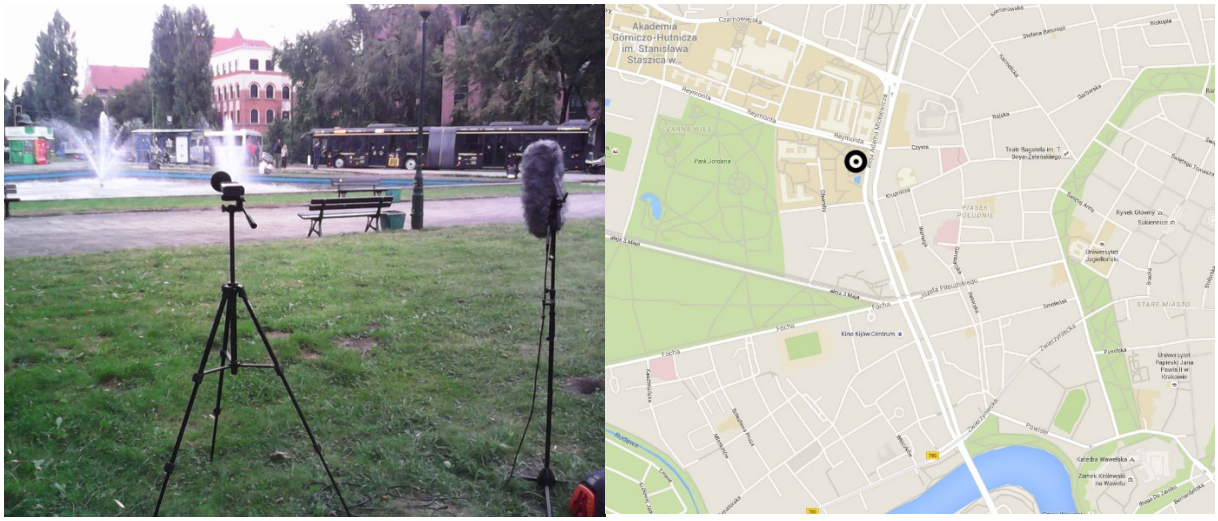


Figure 2 Exemplary photography and marked position from the recording place

Recordings were conducted using first order ambisonic microphone SoundField ST350 with AD/DA converters and preamplifiers integrated in RME Fireface 800 device. Together with the recording, sound pressure levels were measured using SVAN 959 sound analyzer with microphone 40AE by G.R.A.S. and a microphone preamplifier SV12L.

2.2 Stimuli preparation for the tests

The Basic sound decoding used in the research is 1st order ambisonic with HARPEX parametric decoder [14] for 16 channels ‘shotgun’ settings with narrowest possible signal dispersion. The research was conducted in the auralization laboratory which has spatial playback system permanently installed. The laboratory has the following dimensions: 3.9 m x 6.7 m x 2.8 m. The shorter walls are covered by thick curtains, placed 1.25 m from them. The room is acoustically treated with three kinds of APAMA acoustic foam absorbers: panels of 5 cm thickness, 40 cm long wedges, and low frequency cuboids (2 m x 1 m x 0.4 m) behind the curtains as low frequency absorbers. Average RT20 is 0.15 s, calculated from the RT20 at 500 Hz and 1,000 Hz. The laboratory is equipped with a multi-channel setup using the Presonus and Behringer converters and Genelec 6010 monitors. The selected loudspeakers are quite small but their sensitive is 93 dB SPL with flat frequency response from 74 Hz to 18 kHz (±2,5 dB). The loudspeakers are spherically placed around the listener, whose configuration is shown in figure 3.

Figure 3 Loudspeaker setup at Laboratory of Auralization at AGH-UST Krakow

Next used variation was ambisonic decoding with AmbiX decoder [15] for 6 channels evenly placed around the listener in horizontal plain (without altitude). Next samples were prepared with XY stereo 120° technique and cardioid directional characteristics. Another variant was a mono signal (W component of B-format) sent to 16 speakers at the same time. All the sample variants were normalized in terms of acoustic pressure for the listening point. The calibration was also performed so the levels in the laboratory were the same as in the recording conditions. For the basic decoding (16 channels with HARPEX decoder) samples with different acoustic pressure levels in relation to calibration level were created: -6dB, +3dB, +6dB and +12dB.

3 Listening tests

For the necessity of the listening test, sound samples were created for 3 soundscape variations: a) natural Białowieża forest, b) urban Cracov, c) Urban Cracov with fountain running. For the prepared materials identical variants of spatial signal distribution and loudness level, described in detail in the previous chapter, were made: HARPEX (16ch), AmbiX (6ch), XY (2ch), OMNI (16ch) and additionally for Harpex: -6dB, +3dB, +6dB and +12dB. In summary, 3 soundscape variants of x 8 spatial versions (including ones with different loudness level). Prepared samples were randomly (for specific soundscape) played. The main task for the listener was to assess the immersion of the sample, so the similarity in which the soundscape known to the listener is reflected. The test group assessed the samples with use of 1-10 scale. 1 was used to mark totally unnatural and unrealistic impressions and 10 is a full immersion and very good projection of the simulated place. The length of used samples was approximately 30 s. Listeners could listen to each sample any number of times.

4 Results

The study involved a group of 20 listeners aged 19 to 38 years, including 6 women. None of the listeners had a significant hearing loss problem, most characterized audiologically normal hearing. The results

were analyzed statistically. Probably due to the open nature of the test questions, the results are not conclusive. Figures 4 and 5 shows the graphical interpretation of the results. Figure 4 represents the results calculated for all obtained answers, without concerning the type of examined sounds. The best rating was obtained by the reference signal, so the one with the best spatial distribution and real sound pressure level. Ambisonic without the parametric decoding was also ranked very highly. Unexpectedly, the stereophonic system was ranked very similar. The median and the third quartile are even higher than the ambisonic ones. The monophonic system rating is definitively the lowest as expected, this system was used as validation element, as an anchor.

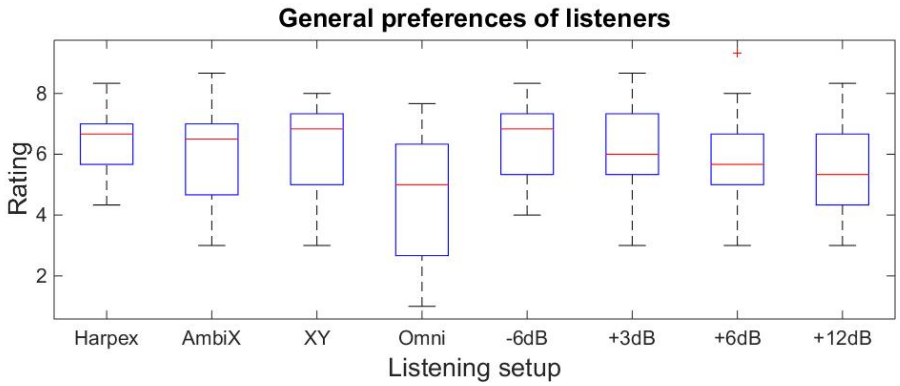
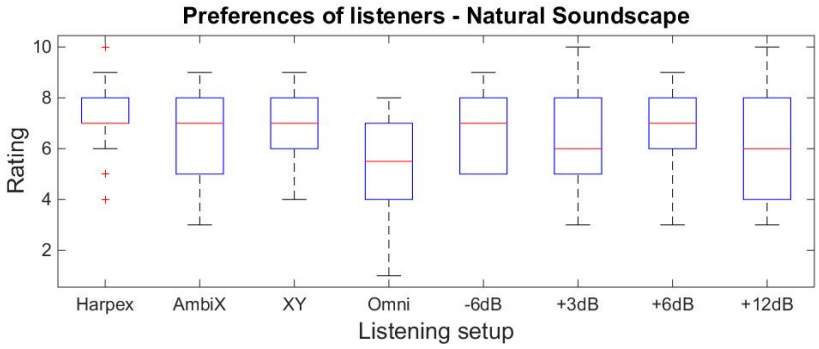


Figure 4 Listeners preference for all the soundscape variants.

The change made to the acoustic pressure in reference to the real situation brought surprising effects. Reduction of the sound level by 6dB almost didn't affect the immersion. Every increase of the sound level affected the listeners rating negatively. Figure 5 summarizes the results obtained by the soundscape variants. The natural soundscape provided most uniform results. The obtained urban soundscape results were most varied, especially within the particular playback systems and sound levels. Decrease of the sound level in the urban soundscape made huge influence on the obtained listeners immersion. This can indicate that greater listening comfort (lesser noise) distorted the proper rating of the recording reality. The urban soundscape with working fountain did not show similar effect.



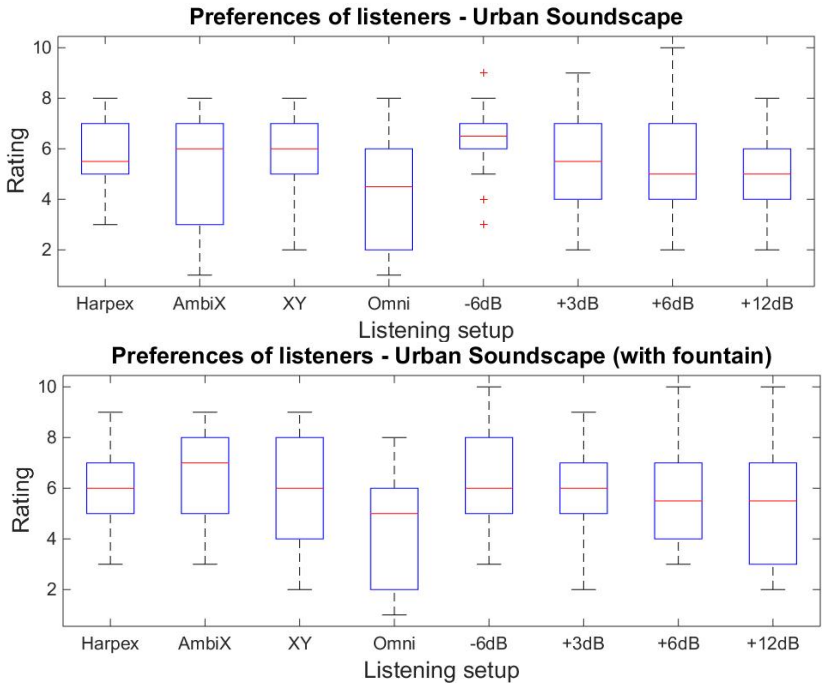


Figure 5 Listeners preferences in relation to soundscapes

5 Conclusions

The article describes the course of experiment which goal was to rate the influence on spatial sound distribution on the immersion level in the soundscape research. This was preliminary research, that showed how to perfect the research goals for obtaining more precise and useful results. Obtained results show that lack of uncorrelated spatial sound influences negatively on the immersion so even two channel stereo system is rated as high as the ambisonic decoding. Surprising was the conclusion about the influence of the sound level on the immersion in the soundscape research. The increase of acoustic level in relation to real one (actual) has very negative influence on the reality of the recording in contrast to the sound level decrease. This conclusion despite its obviousness resulting from the basic properties of psychoacoustics should be implemented in the production of films and music during which the vast majority of sound pressure level of sound events mapping the reality is much too high. In particular regard to the type of 3D recording and by setting the goal to obtaining the highest immersion level.

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