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Soundscape analysis based on ambisonic recordings executed in a primeval forest

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Abstract

The article shows the analysis of ambisonic recordings registered in the Białowieża Forest. The place is the oldest of its kind in Europe, and it is strictly protected. Within a year, hundreds of hours of ambisonic recordings have been made with respect to day and year variabilities. The Forest is included in the UNESCO World Heritage List and in the light of the new strategy adopted by the European Commission in 2011, all member states of the European Union were obliged to increase their efforts aimed at improvement of the present condition of ecosystems by 2020, with six major objectives for 2020 clearly determined. One of those objectives, which we pursue in our studies, is support at prevention of the loss of global biodiversity. Constant climate and environmental changes, as well as concern about the future generations, oblige us to preserve, or at least, to register the current state, along with the natural soundscape. The analysis of levels, spatial distribution and soundscape layers is shown.

Keywords: natural soundscape, ambisonics

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1 Introduction

The article concerns long-term ambisonic recordings of natural soundscape for analysis purpose and for a posterity. The term 'natural soundscape' is, according to [1], an 'inherent acoustical environment of an area without the presence of human-caused sound'. Today, almost every place of human habitation is surrounded by noise most of the time. With the development of industry the environmental noise is obviously more perceptible. The most significant and common noise source is the road traffic. Additionally, the typical human soundscapes includes also the noise generated by industry, aircraft, railways, craft services, farms, playgrounds, municipal facilities, renovations, and household appliances. Searching for a natural soundscape in Poland the authors have carried out their investigations in the area of the Białowieża National Park. Białowieża Forest has been designated a UNESCO World Heritage Site, a UNESCO Biosphere Reserve, and an EU Natura 2000 Special Area of Conservation. 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 conducive weather conditions. The most of recordings were performed in a spot most remote from human settlements it is a location in the strict nature reserve where it is possible to see all indigenous animals and birds subject to strict species protection in Poland. Also in a spot located close to a road since it serves as an animal feeding point, it is frequented visited by European bisons in the winter. Also in a location on the border between the natural environment and human settlements. It is a meadow in which one can find several species of animals and birds protected in Poland. The closest human dwellings are just 0.5 km away from this location. The Białowieża National Park is situated in the north-east part of Poland, in podlaskie voivodeship (Figure 1).



Figure 1: Exemplary photograph from the recordings and geographical location of Białowieża Forest [2]

Its beginnings can be traced back to 1921, when the “Reserve” forestry was created at the place currently occupied by the Park. The Białowieża Forest covers the area of 5725,75 ha and is under strict protection. Białowieża Forest is the last natural forest at the European Lowland Area, having the primaeval character, identical with the one which covered the area of deciduous and coniferous forests years ago. The characteristic feature of the park is its biological diversity. The Białowieża Forest comprises about 809 vascular plants species, over 3 thousand cryptogams and fungi species, almost 200 moss species and 283 lichen species. There have been more than 8 thousand invertebrates species, approximately 120 species of breeding birds and 52 mammal species. Old, primaeval forest stands in Białowieża National Park are characterized by large amounts of deadwood at the various stage of disintegration, and by the presence of typical natural forest species. Apart from Białowieża Forest, many of the aforementioned species can be identified only in few places worldwide. European bison – the biggest European land mammal [3], [2].

2 Ambisonic recordings

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 recordings, sound pressure levels were measured using SVAN 959 sound analyzer with microphone 40AE by G.R.A.S. and a microphone preamplifier SV12L. Recordings of natural soundscape at the Białowieża Forest were carried out from August 2014 to June 2015. The recordings and measurements were made during every of the four seasons of the year. B-format material of over 160 GB was recorded, which constitutes about 114 hours of recordings with the sampling frequency of 44 100 Hz and the 24 bits resolution. Recordings were supported by mobile recording station that thanks to solar power and batteries, provides the possibility of long-term recording, without raising the level of background noise. It is equipped with a hard-disk system for storing recordings, a set of analog to digital converters, and a system for monitoring the recorded signal. Size and functionality of the vehicle also allow the installation of racks and microphone stands to provide the required functionality and weather resistance.

3 Signal and background noise

Natural soundscape of Białowieża Forest has a very dynamic range. Except of a spring time, the most dominant condition is silence. The detailed analyse of low level sounds, based on those recordings has been already provided at [4]. In a summer and a winter time even light wind produces a leaves noise, which sound spectrum depends on tree type. Another ambient sounds are produced by deers during rut season and by crickets and other insects during warm days. Furthermore, the Białowieża Forest soundscape is a sum of singular sound events caused by particular species. Following graphs (figures 2-4) shows A-weighted sound pressure level values for chosen spring and winter time periods.

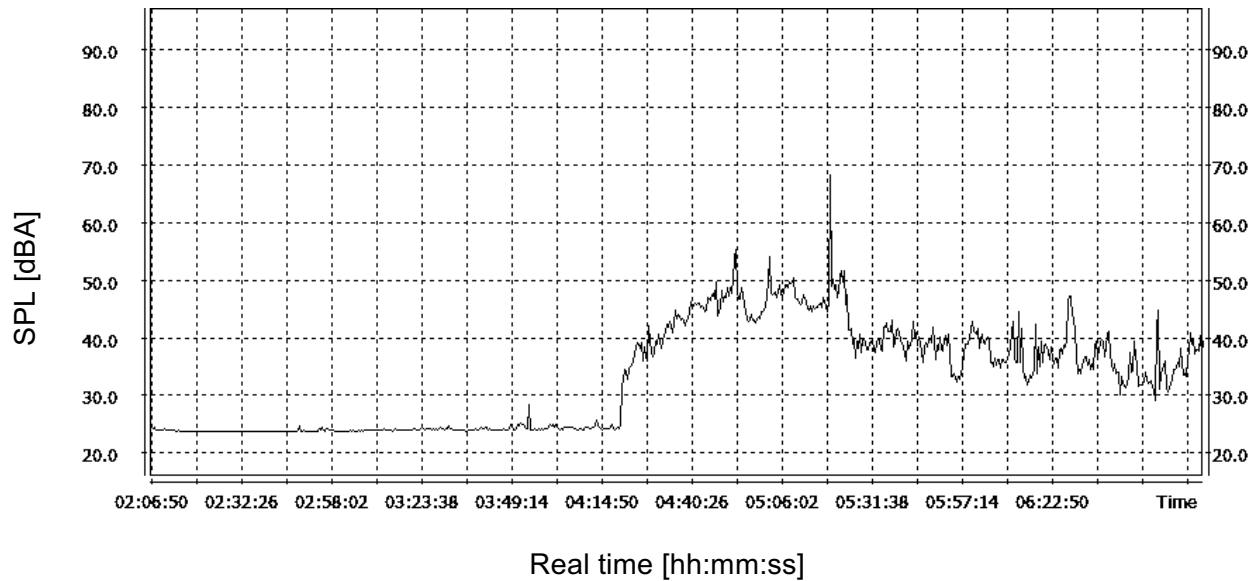


Figure 2: A-weighted sound pressure level values of spring night and morning (2015-04-18)

During the spring night, there are some time intervals where there is no sounds that exceeds noise floor of measurement instruments. Sunrise at the one of measurement days (2015-04-18) was at 5:22 am. On the basis of the figure 2 it can be noticed, that acoustic activity of birds starts about an hour before that. Sound pressure level rises from silence to about 40-50 dBA for around a half of hour. Then, it continues for almost whole day at the similar levels (figure 3).

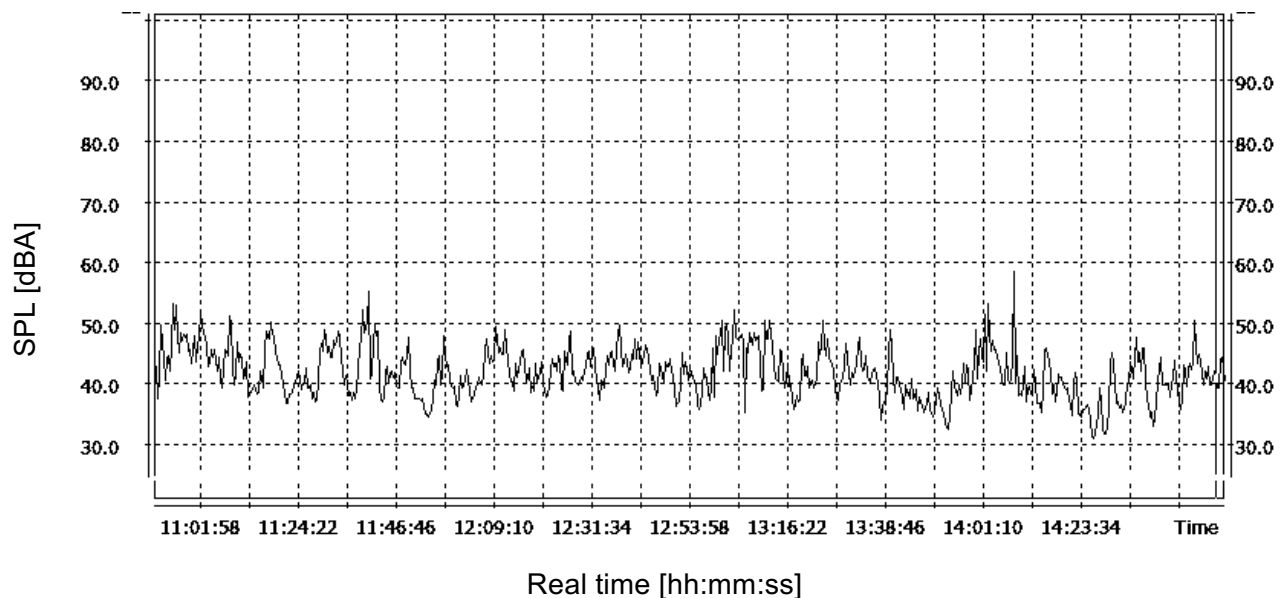


Figure 3: A-weighted sound pressure level values of spring day (2015-04-17)

Analysis of similar time period in the winter shows that there are some singular acoustic events at the night and day time, but their sound pressure levels are much lower than in the spring time. In the figure 4, one can stated very low sound levels that occur quite rarely.

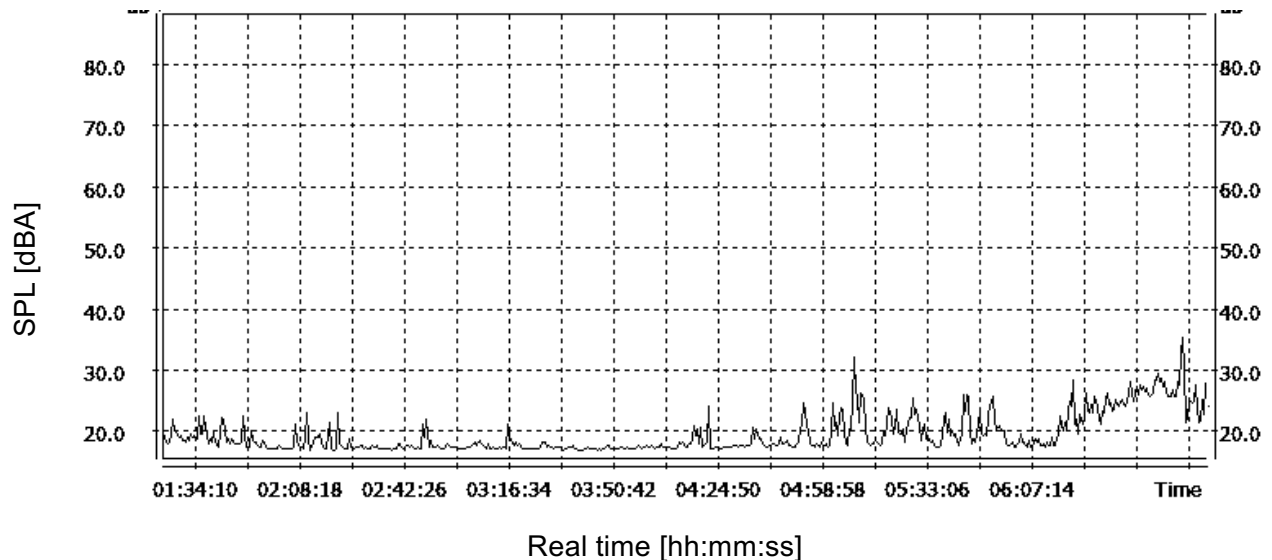


Figure 4: A-weighted sound pressure level values of winter night and morning (2015-02-05)

Sound pressure levels of singular acoustic events at the Bialowieza Forest differs a lot and depends on many factors. Especially it is a result of a individual features of particular organism as well as context of that events. In most cases sound pressure levels do not exceeds 50-60 dBA, and this differences are caused mostly by dystance of sound sources from measurement instruments.

4 Natural soundscape playback

Further analysis of sounds, especially their spatial distribution were performed during off-line listenings in laboratory conditions. The aim was to achieve maximum fidelity and immersion and as accurate reproduction of actual soundscape as possible. For this purpose several sound systems, loudspeaker layouts and codecs were tested. The basic sound decoding used in the analysis is 1st order ambisonic with HARPEX parametric decoder [5] for 16 channels 'shotgun' settings with narrowest possible signal dispersion. The listening 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 ($\pm 2,5$ dB). The loudspeakers are spherically placed around the listener, whose configuration is shown in figure 5. Next used variation was ambisonic decoding with AmbiX decoder [6] 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.



Figure 5: Loudspeaker setup at Laboratory of Auralization at AGH-UST Krakow

In order to compare the sound systems, an anchor was needed. 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. 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. The test involving a group of 20 listeners aged 19 to 38 years, including 6 women was performed. None of the listeners had a significant hearing loss problem, most characterized audiologically normal hearing. The results were analyzed statistically.

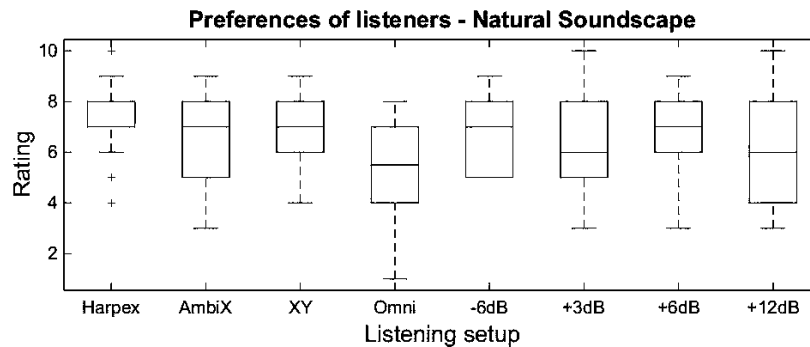


Figure 6: Listeners preferences of levels and playback system for natural soundscape

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 monophonic system rating is definitively the lowest as expected. 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 7: Sounds of Bialowieza Forest DVD cover with visualization of sound localization and its spectral content

Except of analysis by scientists, recorded material was also compiled and shared to the broad audience by DVD with selected sounds in three file formats. In the 5.1 arrangement – as a DVD

soundtrack, as a binaural recording designed for sound players equipped with headphones, and as an ambisonic B-format material that can be played on any loudspeaker system using a parametric decoder or other system. Additionally, the DVD includes a visualization of sound direction (provided by Harpex decoder [5]) and spectrogram in order to allow for analysis of so called 'civil scientists'.

5 Conclusions

The recordings and measurements made in a place as unique as the Białowieża Forest, which is a member of the UNESCO World Heritage List, come as important, but not sufficient activities. Further series of similar recordings and measurements are needed to be done in places equally untamed and abundant where a unique and well-conserved ecosystem still exist. The recordings, measurements and attempts to playback the records, showed that there is a problem with the apparatus' not sufficient range as to the measurements, as well as too much self-noise occurring. In order to achieve the best immersion in laboratory analysis, listening test was performed to use sufficient playback. The best rated system was ambisonics with parametric decoding as it was expected. At the same time, 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.

Acknowledgments

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References

- [1] Maher, R. C. *Obtaining long-term soundscape inventories in the US National Park System*. Montana State University, Bozeman, 2004.
- [2] Małecki, P.; Wiciak, J.; Ozga, A.; Mleczo, D.; Piechowicz, J. *Ambisonic sounds of the ancient forest and the difficulty of silence recording*. ICSA 2015: 3rd International Conference on Spatial Audio, Graz, September 18–20, 2015, in pendrive.
- [3] Białowieża Forest, URL: <http://bpn.com.pl/>
- [4] Wiciak, J.; Mleczo, D.; Ozga, A.; Wszolek, G.; Wierzbicki, J.; Piechowicz, J.; Małecki, P. Quietness in the Soundscape of the Białowieża National Park, *Acta Physica Polonica A*, 128(1A), 2015, pp A79-A84.
- [5] Berge, S.; Barrett, N. *High angular resolution planewave expansion*. 2nd International Symposium on Ambisonics and Spherical Acoustics, Paris, France, May 6-7 2010, in CD-ROM.
- [6] Kronlachner, M. Ambisonics plug-in suite for production and performance usage, in Linux Audio Conference, Graz, 2013, in CD-ROM.