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ACOUSTICAL ASSESSMENT OF URBAN PUBLIC PLACES

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1 INTRODUCTION

Design and renovation of urban public places require tight co-operation between experts from different specific fields. Only a careful design that takes into account several aspects, such as mobility, accessibility, security, density of population, biodiversity, wind, light and acoustical comfort and other, can guarantee the creation of pleasant places appreciated by city users. Urban soundscapes are often considered as a consequence of urban planning, human activity and many other non-acoustical factors, that can be influenced or tuned only within certain limits.

Acoustical assessment of soundscape in an Urban Public Place (UPP) is rather complicated, since no generally accepted standard exist so far. Soundscape assessment methods are under development by many research groups, using different objective or subjective approaches. Objective acoustical methods typically make use of acoustical measurements while considering the physics of sound propagation, and are usually performed by traditional monoaural measurements followed by statistical noise analysis. In some cases also loudness models, binaural recordings analysed by multi-parameter analysis or neural network systems are used.
Subjective methods relate to the opinion of people and usually require advanced socio- or psychological questionnaires or laboratory listening tests. In any case a strong correlation between the human judgement and objective evaluation in situ is always desired.

Each method has its advantages and disadvantages. Objective methods might suffer from the lack of information about the overall perception of sound in a location, but on the other hand, they are independent on subjectivity. Subjective methods can suffer not only from large standard deviations caused by differences in people's opinions, but also from other factors, such as subject's mood or tiredness. Human judgment is often based on the assessment of the urban situation as whole, taking all present factors into account, what makes grasping person's opinion on one specific field (e.g. soundscape) very complicated. The description of wanted acoustical situation in urban context is therefore by default very extended and should probably be defined in a different way than the one we are used to.

1.1 Existing assessment methods

Looking at already existing standardized methods, a strong preference of creators of norms is found to use a single value assessment. Standardized methods are typically focusing on objective noise quantification defined through equivalent sound level or through parameters such as the traffic noise index and estimates for the level of noise pollution[1-3]. Widely used noise regulations are also produced by the World Health Organization, OECD and different national organisations[4,5].

In parallel with the single value assessment methods a large variety of non-standardized soundscape assessment methods based on different approaches, such as, sound(scape) recognition, identification, mapping or categorisation, holistic approaches or advanced sociological methods, have been proposed[6-12].

Our study is based on the hypothesis that the human expectation in urban public place plays a dominant role in its judgement. If people get what they expect they usually feel satisfied. Larger cities can supply a variety of different urban public places so that each person can chose his/her preferred place to go for shopping, jogging, or resting. Soundscape expectation is typically interconnected with other cues such as visual, haptic etc. and with other non-acoustical factors.

This study aims at the development of a method, in which a binaural recording performed in an UPP is automatically sorted into a category, and thus indicateds if the human expectation for the acoustic nature of place can be expected to be fulfilled. The categorization is based on a set of acoustical parameters related to the sound pressure level, psychoacoustical parameters, (roughness, sharpness and fluctuation strength), and binaural information defined via the so-called urban interaural level difference.
To make the evaluation of an UPP complete a second part of the method is proposed, that consists of the semantic description of a soundscape in situ, by using 3 categories (soundmark, keynote sound and sound signals) related to features of a soundscape that cannot be grasped by the objective acoustical measurement.

2 DESCRIPTION OF THE PROPOSED METHOD

2.1 Sound recordings, analysis and clustering

A relatively large set of recordings (370) has been performed in urban public places, i.e. streets, squares and parks, where the acoustical situation has been judged by people as “normal” or “typical”. Sound samples of duration of 15-20 minutes have been binaurally recorded during so-called “soundwalks (SW)” by using in-ear microphones. All recorded data were stored into a solid-state memory of the M-Audio® recorder in binaural wave format.
The recordings were later on analyzed with respect to thirteen acoustical parameters (based on A-weighted sound pressure level $L_{p,A}$, three psychoacoustical parameters: Sharpenss S, Roughness R, Fluctuation strength F and one binaural parameter *uILD*). The first four parameters were calculated in time domain by 01dB Sonic®software and followed by statistical analysis in home-made Matlab® routine where each parameter was expressed by values of the parameter that has been exceeded during a fraction of x % of the recording time (L_x, R_x, S_x and F_x). A binaural parameter *uILD* has been calculated according to an algorithm described in Rychtarikova et al (2008)[13]. Finally, an optimized set of the 13 following variables has been chosen as: L_5, L_{50}, L_{95}, F_{10}, F_{50}, F_{95}, R_{10}, R_{50}, R_{95}, S_5, S_{50}, S_{95} and $uILD_2$.

Figure 1 Example of a cluster No. 7 with a photo of one of the parks clustered in it

Values of thirteen acoustical parameters were calculated for each recording, normalized and used in clustering analysis. Twenty different clusters were created by using hierarchical agglomerative clustering, available in the SPSS®software. The resulting clusters have been verified by manual identification of similarities between acoustical as well as non-acoustical properties of recordings clustered together and by identifying differences between different clusters.

Most of the sound samples were clustered consistent with objective and subjective expectations. Each cluster could be (objectively) visualized by a radar plot and (subjectively) by a verbal comment describing the common features of the places clustered together. E.g. Cluster 1 includes “streets without or with little traffic, with a speed limit of 30 km/h, typically a side street in a residential area in urban zone during day time, when most of the people are at work and side streets in the city center with a combined function, during the periods when shops are closed.” Cluster 2 contains the same places as cluster 1, with the difference that the recordings were performed during the morning and evening hours when most of the people are leaving homes or coming back from work”.

Figure 1 shows the example of cluster 7, which contains recordings performed during the daytime in city parks situated very close to main roads in an urban zone with large grass surfaces or a lake not protected from the traffic noise where the speed of cars almost never drops under 50 km/h. A detailed overview and analysis of a total of 20 clusters is given in Rychtarikova and Vermeir, 2010[14].

2.2 Semantic assessment

Automatic categorisation of a soundscape (or sound event) in a particular UPP can be successfully obtained from binaural recording in situ by the above describe method. However, to have a full impression of the evaluated soundscape, some semantic categories need to be proposed. Inspired by the book of Shaffer, three verbal categories were chosen for soundscape assessment of UPPs. (1) Soundmark, understood as a sound which is unique to an area, based on which a place can be identiffied (2) Keynote sound, as kind of amorphous sound that may not always be heard consciously, but that ‘outline the character’ of the people living there. This sound can be created by nature or by permanently present sound sources. (3) Sound signals, defined as foreground sounds listened consciously, such a warning devices, bells, whistles, horns, sirens, etc which can be localized.

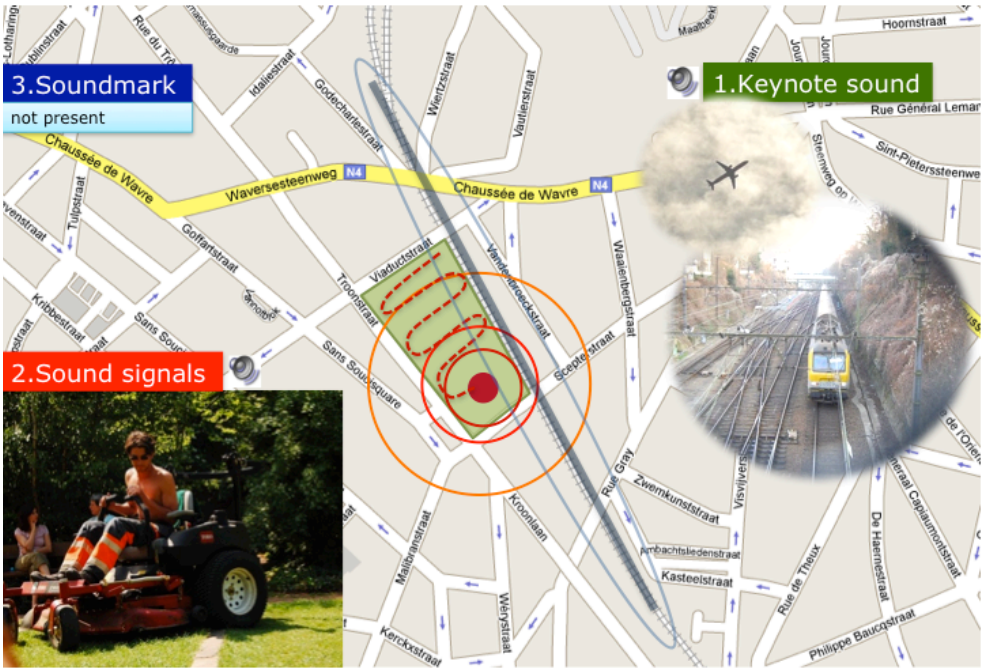

Figure 3 Example one of the case studies in Brussels (Viaduct park), analysed by proposed semantic categories

An example of a analysed UPP ((Viaduct park in Brussel) is shown in figure 2, where a distant train sound as well as airplane sound together with typical park sounds, such as moving leaves and bird sound in the summer became a keynote sound in this park. This example belongs to cases, where sounds of nature are mixed with permanently present sound sources and are perceived as

background amorphous sound. During the summer, sound signals in the park are coming from gardening machines that are used for the maintenance of the park. No Soundmarks were found in this park that would make it unique or special in comparison with other similar parks in Brussels.

3 CONCLUSIONS

This study is related to the question to what detail the differentiation between particular UPP or sound events can be successfully performed by using only objective acoustical parameters and which information/categories are necessary to be included in semantic assessment if we like to have a global soundscape description of an UPP. Twenty clusters identified in this study reflect typical acoustical situations in particular UPPs or special sound events in typical urban situation in Belgian cities. This database does not include all kinds of possible soundscapes that might exist in other countries, but new clusters can be created in future once recordings from other places would be available.
It is obvious that a single value assessment can be hardly applied when speaking about soundscape. An extension of the the single value approach to a hybrid clustering method that is based on the current acoustic measures, enriched by a semantic description, in terms of e.g. Soundmark, Sound signals and Keynote Sound in the UPP, can be expected to give a more complete and essential impression of evaluated soundscapes.

4 ACKNOWLEDGEMENTS

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