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Noise masking as a soundscaping measuring procedure

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Loudness is the perceived intensity of a sound that could solve the problem of measuring a sound that is already filtered by the listening procedure. However, technically it is impossible to separate physically the sources of a noise into its components as well as human perception does. Loudness cannot be operative if a sound is merged with other noises. The principle of the proposed solution consists on gradually mixing a white noise during listening until the selected sound that one wants to measure is totally masked. The level of the masking white noise is controlled independently from the listener and measured with dB(A). The listener controls the limit of audibility of the selected sound, which is masked by the white noise. This paper describes the patent deposited around this method and shows the results obtained so far, and how this technique can be helpful in a visual translation of the sound space composition.
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1 Introduction

Tools and methods for measuring sounds are numerous and precise. Focusing on the signal, acoustics can describe, calculate and simulate the behaviour of sounds with a very high precision. On the other hand, psychoacoustics focuses on the psychological and physiological principles of sound perception. However, in complex situations such as urban sound ambiances, it is still difficult to measure and separate the sounds of that surrounding soundscape. Let one notice that a listener can intuitively do that.

A new procedure and measure that allows the assessment of the imbedded sounds in a soundscape, ranging from the louder to the unheard or masked one, as in an analogous way to human perception is presented here.

2 Assumptions

The main assumption of this work is based on the Zwicker and Scharf [1] experiments of masking when two tones were compared. The first tone (masker) is set to some fixed frequency and intensity. The second tone (test) is varied in frequency and intensity until it is masked by the first one. Therefore, the hypothesis is to consider a white noise, covering all frequencies as the masker of any sound having the same intensity of the loudest spectral component. If this is true, the level of the white noise becomes the measure of the highest frequency of any sound in the soundscape. The following question is now pertinent: is the experience of the two tones transposable to a complex sound coupled with white noise?.

3 Testing Method

Tests were performed by using professional headphones and a computer in a quite room. Music composition software was used for mixing. The masking white noise was generated by the computer (Figure 1).

Various sounds were tested in mono format presented binaurally:

• Recorded human voice reading text in a quiet room

• Synthetic orchestral strings playing A4 (440Hz) with reverberation

• Synthetic cathedral organ playing A4 with added reverberation

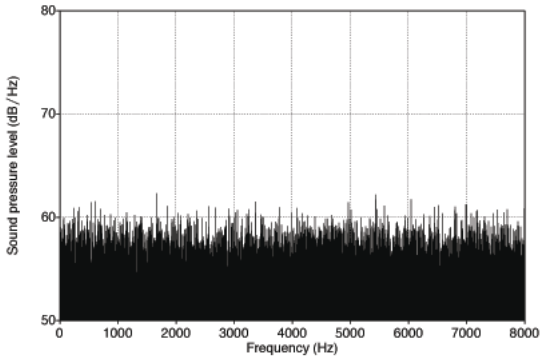

Fig. 1 masking white noise measured at 60 dB (SPL)

When mixing the white noise with these sounds separately, the level of each sound was lowered until it is totally masked by the white noise. The white noise and all the tested sounds were recorded to disc in audio format. Spectral analysis was applied to each sample.

The listening level was increased in the beginning of the test until a comfortable level of listening was reached. However, it was important to focus on the difference between the masker and masked sound levels.

The results correspond to one listener with normal hearing. Other listeners have obtained the same results with only 3dB of difference. Since the aim of this method is to measure objectively, but using the perception ability of only one subject as the measuring apparatus, it was not considered necessary to perform tests on a large panel of subjects. The results from one subject were seen to be sufficient. In fact, a better or a worst human quality of listening applied in this method of assessment corresponds to a high or low quality sound level meter used in classical measurements. Human sensitivity and perception are used instead of microphone sensitivity and high precision of signal processing of sound level meter.

4 Results

The results conformed to the original expectations. The level of the loudest spectral component for of each sound was nearly equal to the level of the white noise (measured at 60 dB)

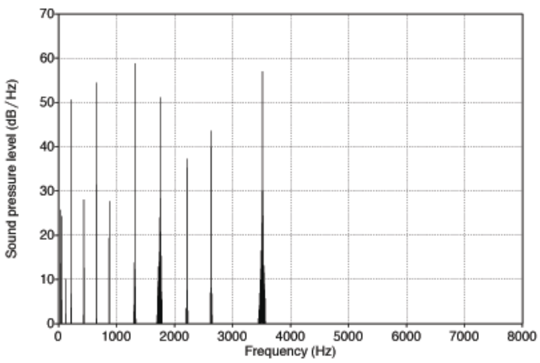

Fig. 2 Cathedral organ spectrum (A4) masked by a white noise of 60 dB

In the case of the cathedral organ, the louder frequency reaches 59dB at 1320 Hz.

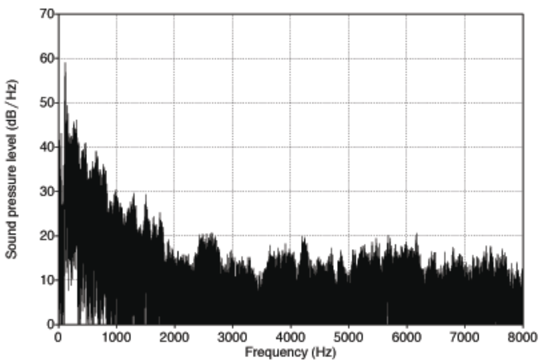

Fig. 3 Human voice reading a text (recorded in situ) masked by a white noise of 60 dB

The louder frequency of the human voice reaches 59dB.

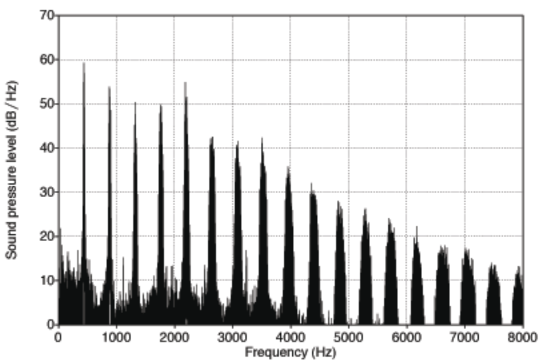

Fig. 4 Orchestral strings spectrum (A4) masked by a white noise of 60 dB

The louder frequency of orchestral strings was measured at 60dB.

5 Discussion

The experiment of Zwicker & Schaft is transposable for complex sounds. The results presented here confirm that any complex sound is totally masked by a white noise with an overall level which is the same as that of its louder frequency. The sound pressure level of the white noise becomes a measure of the masked sound. From the point of view of perception, it is the measure of the “size” of that sound. It measures the perceived sensation of a sound independently of its intensity or equivalent sound level. Although one could argue that this newly proposed concept is no different from the widely known loudness level, the “sound size” is in fact an objective measure whereas loudness is subjective. “Sound size is obtained directly from the masking level of the controlled white noise.

For this reason, one can say that all the sounds measured in this experiment, (voice, organ, ring phone etc.) have the same size for the listener, albeit sound level.

All these sounds need the same level of white noise to be completely masked.

6 Patent

An instrument was invented to allow this measurement experience in situ. a patent was deposited [2].

By introducing a masking and measuring noise in the ambient soundscape, one may, by increasing the acoustic level of the white noise, measure *in situ*, each sound of the soundscape. In the other hand, one just listen to the noises mixture detected by the microphone (2), until the sound to be measured is totally hidden.

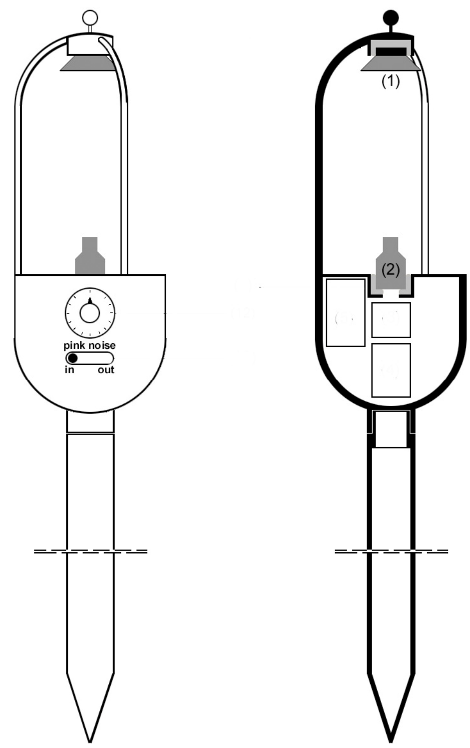

Fig. 5 Sound sizes measuring instrument

7 The sound sizes

The perceived sound sizes correspond to the unmasked part of a sound in a local place. For example, if it is needed 9 dB to totally mask the sound of a fountain in an urban place, so the perceived sound size of that fountain is 9 dB from that point of listening. If the fountain is initially unheard, (its perceived sound size is zero) it means that the naturally masked fountain in that local point is lower or equal to the natural background noise. If the background sound drops down, the fountain becomes heard once again. So the sound size is a measure that depends on the distance from the source, and the existing background noise. It is measured locally from the perceiver location.

Sound Size = Perceived Size + Masked size.

Additionally, the curves of perceived sound size can be interpreted as the behaviour of the source (fountain) with urban background noise, which is known to have similar characteristics to with noise (Figure 6).

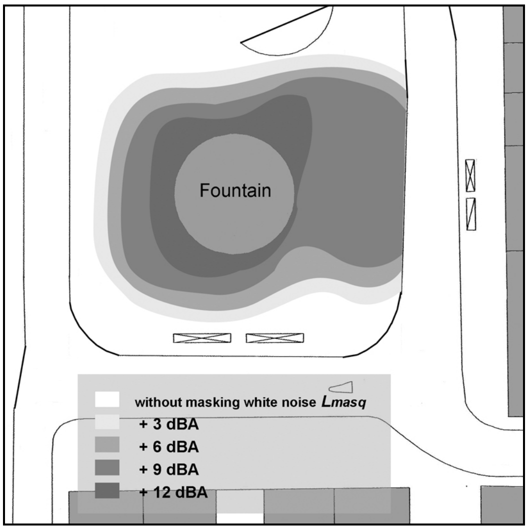

Fig. 6 Qualitative representation of the fountain sound in Rossio square in Lisbon

As the process of measurement is based on the listening, it becomes easy to separate the sounds imbedded in the same soundscape [3]. The process of separation is based on the well-known cocktail-party effect.

Figure 6 represents a qualitative map using the method of separating sources applied to a number of points covering an urban area.

The different curves of the same source plotted in 3 dB steps are a good representation of the behaviour of the sound topology of that source with its background and the other sources of the soundscape.

The quality of the soundscape becomes easily and quickly readable in any local place of the area without listening (Figure 8).

When many perceived sound sizes are close to zero because of a loud background noise, the soundscape has a bad intelligibility. It is a low-fi quality of that soundscape regarding to M. Shafer theory [4]. It becomes a hi-fi soundscape if the ratio between each source and the background is inversed. However, if the background noise is defined as the unwanted sound, this ratio becomes very subjective in domestic sound situations because there is no consensus about the unwanted sounds. For example, music can be perceived as noise by the neighbours.

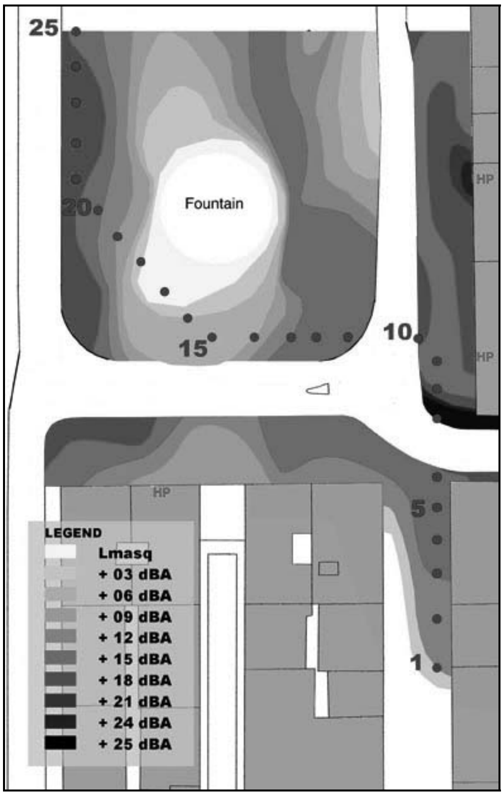

Fig.7 Qualitative representation of the traffic noise in Rossio square in Lisbon

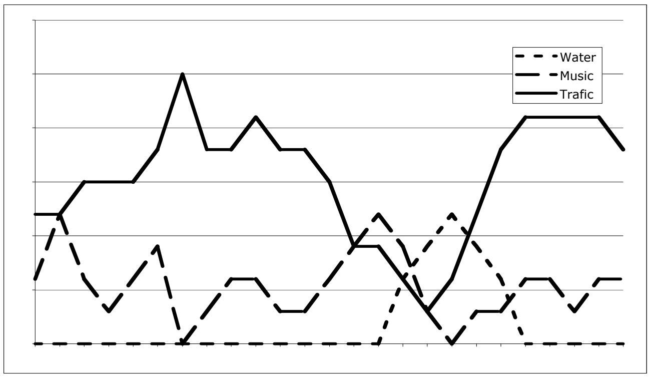

Fig.8 Soundscape composition for a walk course in Rossio Square

Moreover, little background noise of the outside traffic can be helpful to mask some neighbourhood noise [5]

8 Conclusion

The results showed that the introduction of human perception during the process of analysis makes it possible to target the measurements to one or more noise sources selected separately from their background noise. Contrary to conventional measurements, which yield overall values of LAeq, without distinguishing sources, the new method described herein allows a space description of a soundscape by standing out each sound form from its context.

Acknowledgments

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References

[1] E. Zwicker, B. Scharf, “Model of loudness summation.” Psychological review, 72, 3-26, (1965)

[2] M. Boubezari, “Dispositif Portatif de mesure des courbes d'isophonie d'une source de bruit par effet de masque acoustique et son procédé d'utilisation”. Brevet n° 01 14250 du 03 nov 2001, INPI Grenoble

[3] M. Boubezari and J. L. Bento Coelho, “Sound topologies as a spatial description of the soundscape, the qualitative sound map of Rossio square in Lisbon” , Congrès commun, CFA/DAGA '04, Strasbourg France, 22.-25, Mars.2004

[4] R. M. Schafer, The tunning of the world, Alfred A. Knopf, New York, 1977

[5] M. Boubezari, Méthode exploratoire sur les pratiques intuitives de maitrise du confort acoustique en milieu habité, P.H.D. Cresson, Grenoble 2001