

An Internet-Oriented System for Acoustic Measurements of Sound Fields

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Summary: Based on the model of auditory-brain system, a new diagnostic system was developed. The system including the AD and DA converters works on PC for Windows, thus it is no need for special additional devices. Further, the system is available on internet, where a user can obtain further information about the system, and utilize it easily in practice by the download of a demonstration program. After obtaining the binaural impulse responses, four orthogonal factors including the SPL, the initial time delay gap between the direct sound and the first reflection, the subsequent reverberation time, the IACC and others are analyzed. Then, these factors may be used for the calculation of the scale values of both global and individual subjective preference for sound fields. In addition, two more factors, I_{IACC} and W_{IACC} in the interaural crosscorrelation function are figured out for evaluating the image shift or balance of sound fields and the apparent source width (ASW), respectively. Also, the effective duration of ACF, τ_e , and fine structures of autocorrelation function of sound signals including the value of first maximum, τ_1 and its delay time τ_{d1} are analyzed. This system may be utilized for environmental noise measurements, including identification of noise and directional and spatial information as well as loudness information.

INTRODUCTION

In order to measure orthogonal factors, SPL, τ_1 , T_{sub} , IACC, I_{IACC} , and W_{IACC} [1-6], and also the running ACF of sound field at each seat in a scale model as well as in a real auditorium, a diagnostic system is developed. Based on the model of auditory-brain system which consists of the autocorrelation mechanism, the interaural crosscorrelation mechanism between the both auditory pathways, and the specialization of human cerebral hemispheres [1], a diagnostic system was developed. The system works on PC for Windows with an AD & DA converters, thus it is no need for special additional devices. After obtaining the binaural impulse responses, four orthogonal factors including the SPL, the initial time delay gap between the direct sound and the first reflection, the subsequent reverberation time and the IACC are analyzed. These factors are used for the calculation of both the scale values of global and individual subjective preferences. In addition to the four factors, two more factors, I_{IACC} and W_{IACC} , extracted from the interaural crosscorrelation function can be figured out for evaluating the image shift of sound source and the apparent source width [6], respectively. Also, the averaged sound energy for two ears, the effective duration, τ_e , defined by the delay at which the envelope of normalized ACF becomes 0.1, and fine structures of autocorrelation function of sound signals including the magnitude of first maximum, τ_1 , and its delay time, τ_{d1} , of source signals are analyzed. Also, for the internet based measurement

of environmental noise, this system may be utilized for identifying source signals and spatial information.

OUTLINE OF A DIAGNOSTIC SYSTEM

The period of maximum-length signal (MLS) was between 1024 and 524288 samples, and the sampling rate can be changed between 8 kHz and 48 kHz. The acoustic signal amplified from the two microphones placed at the entrances of ears of dummy head was sampled after passing through a low pass filter. The binaural-impulse-response measurement may be performed by a summation of the output data from the linear system, without any multiplication operation [7, 8]. It took another few seconds for the analysis of the orthogonal acoustic factors mentioned above and the scale value of subjective preference. This system may be utilized for automatic environmental noise measurements.

THE INTERNET-ORIENTED SYSTEM FOR MEASURING THE NOISE WITH DUMMY-HEAD MICROPHONES

Measurement of environmental noise is illustrated in **FIGURE 1**. The purpose is measuring an influence which an airport have on the region. This is an example of technical application of the concert hall measurement system [9, 10] for the internet technology.

The measurement is performed by two channels on each measuring point, where the collected data are distinguished the aircraft noise from the others automatically [11, 12].

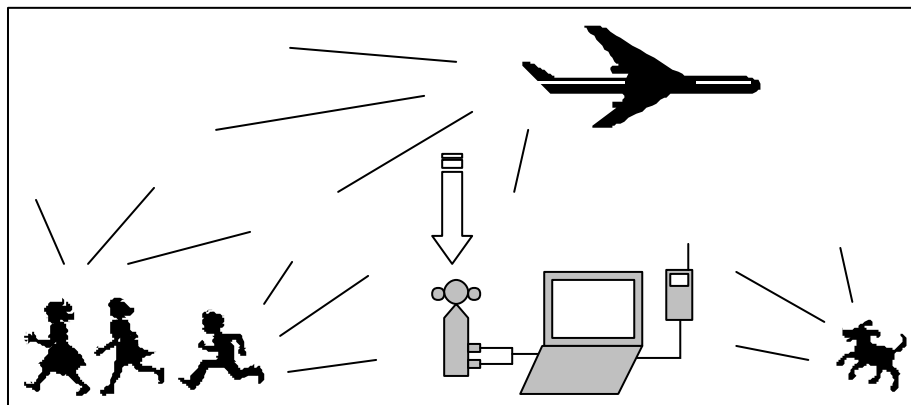


FIGURE 1. The internet-oriented system for measuring environmental noise with dummy-head microphones; The system identifies, for example, the aircraft noise.

In case of the aircraft noise, it is analyzed there, and is sent to central office through internet. Primary sensations, pitch, loudness and timbre, of a given source signal and sound field are described based on a model of auditory-brain system [1]. The model consists of both autocorrelation and interaural crosscorrelation mechanisms. In order to describe timbre or quality of sound fields, for example, the human cerebral hemisphere specialization for the temporal and spatial factors is taken into consideration as the similar manner to the subjective preference.

As this result, by sending only these parameters, it is not necessary to send whole sound

data obtained by measurement. The diagnostic system may be applied to the internet by sampling environmental noise.

1. Identification of a noise source: The noise is identified as that of an aircraft, an automobile, a factory and so on, by using four factors extracted from ACF; $\rho(0)$, τ_e , τ_1 , and τ_{-1} (FIGURE 2, 3). It is the same method that is used for the speech intelligibility of single syllables [11].

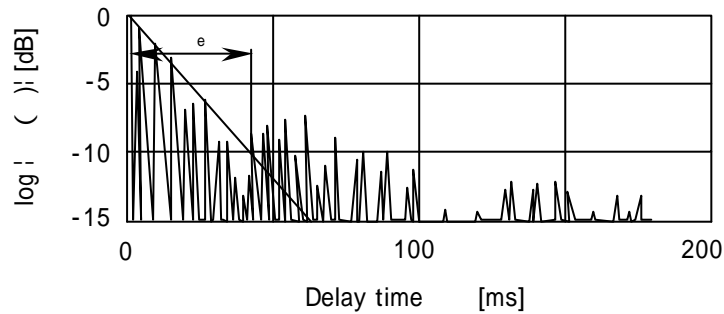


FIGURE 2. A practical example of determining effective duration of ACF defined by the ten-percentile delay, with the straight line-fitting envelope of ACF from 0 to -5 dB.

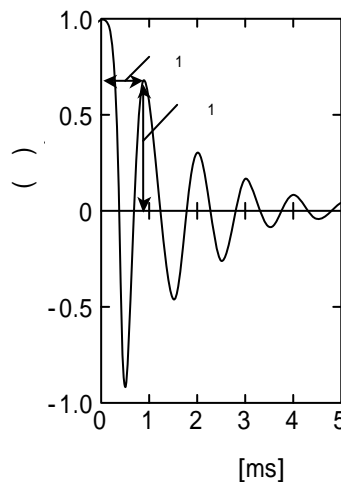


FIGURE 3. Definitions of the τ_1 and τ_{-1} for the autocorrelation function.

There are four orthogonal factors of sound fields, namely, listening level LL, initial time delay gap between the direct sound and the first reflection τ_1 , subsequent reverberation time T_{sub} , and IACC. The IACC (maximum of the IACF) is related to the subjective diffuseness. In addition to the IACC, τ_{IACC} (delay time at the IACC obtained) and W_{IACC} (width of the maximum) extracted from the IACF are deeply related to the image shift of sound source and the apparent source width (ASW), respectively. All of these factors must be considered to describe the primary sensations as well as the subjective preference [12].

2. The noise level: listening level LL at both ears. (1)

$$LL = [\rho_{ll}(0) \rho_{rr}(0)]^{1/2} \quad (1)$$

3. The spatial information, for example, may be expressed by

$$s_t = f_t (LL, IACC, W_{IACC}, IACC)_{right} \quad (2)$$

A further information of the internet-oriented diagnostic system can be found at: <http://www.ymec.co.jp/>.

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