Room Acoustic Evaluation of Small Rooms

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Abstract: Searching for the relationships between the subjective aspects and sound field properties needs great experimental efforts. Much more subjective and corresponding objective parameters has been found for room acoustic evaluation of concert halls than of small rooms. The recording studios, broadcasting studios and control rooms are usually small in the acoustic sense. The issue is that it is difficult to say what is good enough? In this paper the authors present some parameters for room acoustical evaluation of small rooms based on the M-factor, the n-th momentum of distribution, middle time and clarity. In the paper the results of listening tests and of measurements are given. Another issue is that how to predict the quality of the sound field in a small room. An acoustical computer model has been carried out. A comparison between simulated and measured parameters is presented.

INTRODUCTION

Broadcasting studios, control rooms and listening rooms are usually small. Since in practice there are by far less objective acoustical parameters proposed for small rooms than for concert halls, it would be useful for a designer to find new objective parameters which correspond to the subjective side. The aim of our working group is to find new objective parameters on the basis of subjective test from the measured impulse responses. Using the new objective parameters with our modeling program the acoustical quality of the sound field can be predicted.

SUBJECTIVE INVESTIGATIONS

In order to find relationships between objective and subjective parameters several subjective tests were carried out [1]. Subjects of the tests were experts and students. After an ear-training, a 40 minutes long demo record was selected. This record was listened to in the reference listening room of the Hungarian Radio, regarding the result as the main impression. In other rooms after listening to the test records, the participants filled out a questionnaire with questions about stereo impression, timbre, spatial impression, frequency response, room modes, other resonances, noise from outside, noise from equipment, main impression and comfort impression.

ACOUSTICAL MEASUREMENT

Acoustical measurements were carried out in the rooms mentioned above by using an MLSSA analyzer of DRA Laboratories. From the different measured impulse responses besides the known parameters new ones were calculated. In the first part of our listening tests we investigated only control rooms, so we give parameters for them. These parameters are based on the time domain integrals of energy, such as:

$$E_{(t_1,t_2)} = \int_{t_1}^{t_2} p^2(t)dt \qquad (1)$$

with different time intervals [2]. The evaluation program we developed is flexible enough to calculate different values with time integrals and suitable for different statistical analysis. Finally the results can be viewed (Fig. 1.).

MODELING OF ROOM ACOUSTICS

Computer aided room acoustics modeling is a well described topic in literature (for a short summary see e.g. [3]). There are several different modeling systems available and most of them utilize the simplifications of geometrical acoustics. Considering the linear size of relevant surfaces, geometrical acoustics is adequate for relatively high frequencies only. For the low frequency properties of a room, numerical approximation of the wave equations is needed. This leads to the methods of finite elements, boundary elements or finite differences. These have an upper frequency limit determined by the size of the elements or the size of the steps. If we try to reach higher frequency limits, the computational effort becomes prohibitive.

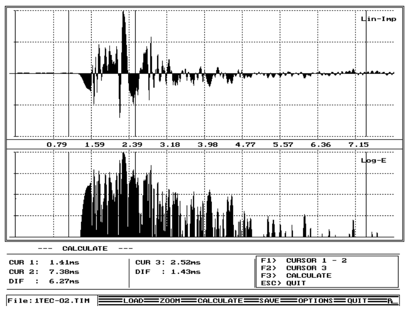

FIGURE 1. Main screen of the evaluation program

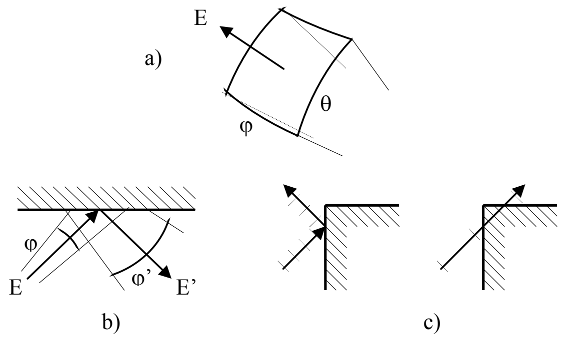

FIGURE 2. Details of modeling ray paths
a) cone-surface, b) diffuse reflection, c) sensitivity

Modeling the acoustics of listening and control rooms is a special challenge, because they are typically small, the influence of the furniture is not negligible, their surfaces are made of special materials and the model must be accurate enough to predict non-statistical parameters with admissible errors as well. To solve these problems we developed a model based on geometrical acoustics with simple approximations of low frequency properties. The only reason using finite element models was to extract individual modes of a given room geometry.

MODELING IN DETAIL

Geometrical acoustic model implementations include image-source and ray-tracing models or their combinations. Cone-tracing is a hybrid method where a ray has finite dimensions to have an exact intersection with point-like receivers.

Our cone-tracing model was developed originally to simulate impulse responses of rooms with arbitrary geometry aimed at investigating artificial reverberation algorithms. One ray represents here a piece of the spherical wave as shown in Fig. 2.a., which is basically described with its energy, angles φ and θ and distance from the original source. Diffuse reflection is modeled with changing of the angles φ and/or θ (Fig. 2.b.). Distortion of the cone surface due to curvature of a reflecting surface is corrected. A ray may be split up into four rays on the first extreme diffusing surface. Low-frequency properties of wave propagation may be modeled either by a simple edge-diffraction model or by setting the sensitivity in searching for reflections (Fig. 2.c.). The latter gives an upper frequency limit due to the sampling property of the finite step size.

The ray paths and parameters are collected and stored, animated visualization of the wave propagation is possible. In the post processing phase detection is computed from the parameters of receivers, eventually the impulse response is calculated. Without remodeling, the parameters of surface materials and sources may be modified. From the impulse response the desired parameters may be calculated and compared to the measured ones.

CONCLUSION

Our examinations show new possibilities in classification of small and control rooms with objective parameters derived from measured and simulated impulse responses.

REFERENCES

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However even in the extreme case of a car interior, geometrical acoustics modeling was still usable down to 350Hz [3]. It may be stated that if the wavelength of the lower frequency limit is determined by the size of the smallest surface area, errors due to the modeling are admissible, but the probability of misapplied reflection modeling depends on the geometry of the room and the configuration of sources and receivers anyway [4].