Measuring sound coloration due to synthesized room reverberation

Noha Korany
E. E. Dept., Faculty of engineering, Alexandria University, Alexandria, Egypt.
Fax: +203 5921853, email: nokorany@hotmail.com

Abstract

The aim of this article is to characterize the sound coloration perceived due to the room reverberation simulated by different methods. The room reverberation is simulated, and the sound coloration perceived is measured. The relation between the sound coloration and the acoustical parameters is discussed and factors affecting the coloration perceived are investigated.

Introduction

Various methods are used to simulate the acoustic response of rooms. A simplified method such as the mirror-image method [1] is employed to partially describe the sound propagation in rooms. A reasonable method for the simulation of sound diffusion in computer models is the specular-radiant method [2] [3]. This method integrates the radiant and the geometrical approaches to simulate rooms with boundaries of partially specular reflectivity.

An important parameter that affects the quality of the sound perceived due to room simulation is the sound coloration.

In this article, the effect of simulating sound diffusion in rooms on the coloration perceived is investigated. Another factor, such as the various distribution of the absorption coefficient of the room boundaries, may affect the sound coloration perceived. The sound coloration is measured for different distribution of the absorption coefficient of the room boundaries over the various frequency bands, and the effect of frequency-dependent absorption coefficient on the sound coloration is investigated. Objective measures are used to characterize the sound coloration due to the simulated room impulse response.

Objective measures for the sound coloration in rooms

In this article, the autocorrelation analysis and the spectral coloration index are employed to characterize the sound coloration in rooms [4] [5].

Using the autocorrelation analysis, a parameter that is called the temporal diffusion index is introduced. The temporal diffusion index, Δ, is defined as the ratio of the central maximum of the autocorrelation function, $\Phi(t=0)$, to the next side maximum, $\Phi(t=\tau_o)$.

The spectral coloration index is defined as the level difference between the maximum and the minimum of the spectrum of the room reverberation.

Effect of simulating diffusion on the sound coloration

A room of dimension 11 x 7 x 3 (m) is simulated by means of the specular-radiant method. The room has a reverberation time that is equal to 1.5 second, and the absorption of the room boundaries is uniformly distributed. The order of reflection is set to 12. The room impulse response is filtered over octave bands and the spectral coloration index is calculated at each band. Moreover, the temporal diffusion index is calculated. The simulation and the calculation are repeated for different values of diffusion coefficient. For diffusion coefficient values d = 0 and d=0.7, the spectral coloration index and the temporal diffusion index are shown in figures 1 and 2 respectively. Less sound coloration is measured for diffusion coefficient = 0, as the corresponding impulse response consists of a less number of reflections [6].

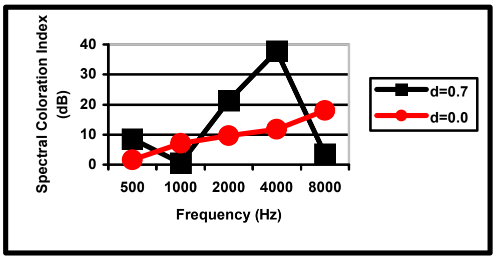

Figure 1: Spectral Coloration Index for d=0, and for d=0.7, where d is the diffusion coefficient.

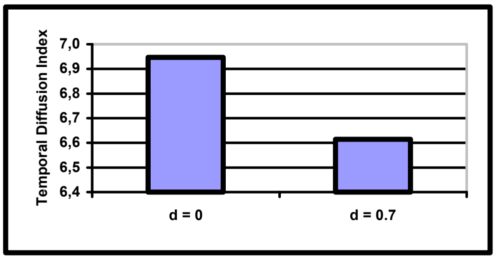

Figure 2: Temporal Diffusion Index for d=0, and for d=0.7, where d is the diffusion coefficient

Effect of frequency-dependent absorption coefficient on the sound coloration

A room of dimension 11 x 7 x 3 (m) is simulated by means of the specular-radiant method. The absorption coefficients of the room boundaries are frequency-dependent. The order of reflection is set to 12. The room impulse response is filtered over octave bands and the spectral coloration index is calculated at each band. Moreover, the temporal diffusion index is calculated. The simulation is repeated for different values of frequency-dependent absorption coefficient. Figure 3 draws the absorption coefficient of the room boundaries over octave bands. Figures 4 and 5 show the corresponding spectral coloration index and the temporal diffusion index respectively.

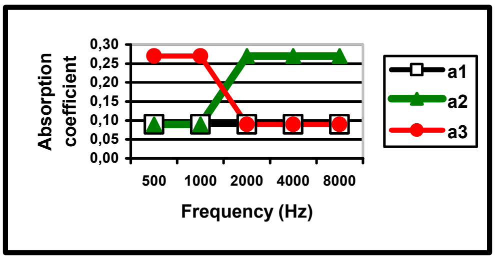

Figure 3: Different values for frequency-dependent absorption coefficients. a1: Uniform absorption coefficient. a2 and a3: frequency-dependent absorption coefficient.

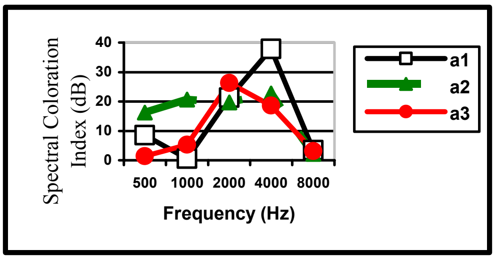

Figure 4: Spectral Coloration Index for the absorption coefficients drawn on figure 3.

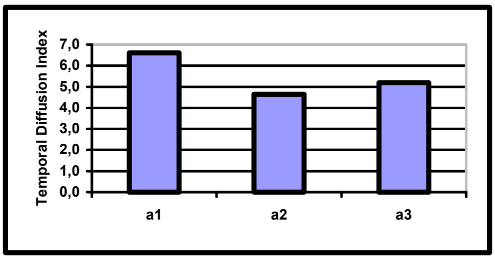

Figure 5: Temporal Diffusion Index for the absorption coefficients drawn on figure 3. a1: Uniform absorption coefficient. a2 and a3: frequency-dependent absorption coefficient.

The least sound coloration is measured for uniform absorption coefficient, a1, whereas the frequency-dependent absorption coefficient, a2, causes the highest sound coloration. Figure 4 shows that the sound coloration is more affected by the absorption coefficients of the frequency bands 500, 1000 and 2000 Hz.

Conclusion

In this article, the sound coloration is characterized for various room impulse responses. The sound coloration measured differs for different values of diffusion coefficient. The coloration measured may be referred to the number of reflections that are calculated over the time-windowed room impulse response. Moreover, the sound coloration is more affected by the distribution of the absorption coefficient of the room boundaries over the frequency bands 500, 1000 and 2000 Hz. A detailed spectrum analysis for the room response may provide better characterization for the sound coloration in rooms.

References

[1] Borish, J., " Extension of the image model to arbitrary polyhedra", JASA 75 (2), 1927 – 1836, 1984.

[2] Korany, N. , " A model for the simulation of sound fields in enclosures integrating the geometrical and the radiant approaches", Doctor thesis, Alexandria Uni., Egypt, 2000.

[3] Korany, N. and Blauert, J. and Abdel Alim, o., "Acoustic simulation of rooms with boundaries of partially specular reflectivity", Applied acoustics 62, 875 – 887, 2001.

[4] Per Rubak, "Coloration in Room Impulse Responses", Joint Baltic-Nordic Acoustics Meeting 2004, 8 – 10 June 2004, Mariehamn, Åland.

[5] Srodecki, K., "Evaluation of the Reverberation Decay Quality in Rooms Using the Autocorrelation Function and the Cepstrum Analysis", Acustica vol. 80, pp. 216 – 225, 1994.

[6] Korany, N., "Computer modeling and auralisation of sound fields in rooms – an overview", ICA 2004, Kyoto, Japan, Mo4.B2.1: I-277 – I-280