Evaluation and Modeling of Small Rooms

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Introduction

Small rooms

Special requirements:
reference listening rooms, technical rooms, …

Special circumstances:
acoustical treatment, small size, equipment, …

Objective

Subjective/objective characterization

Optimized design and modeling method
Evaluation

- Parameters in recommendations
  ... are not thorough enough,
  new parameters are needed

- Developing new objective parameters
  subjective tests correlations?
  measurements correlations?

- Proposed objective parameters
  ... from measure impulse responses
  ... based on energy-time integrals
Objective Parameters that Correlated

“k₁” or “k₂” ~ “stereo accuracy, spatial impression”

\[
k₁(t) = \log_{10} \frac{\int_{0}^{t} p^2(\tau) d\tau}{\int_{0}^{\infty} p^2(\tau) d\tau}
\]

k₂(t) = \log_{10} \frac{\int_{0}^{t} p^2(\tau) d\tau}{\int_{0}^{\infty} p^2(\tau) d\tau}

“M” ~ “timbre”  \quad M = k₂(20ms) - k₂(5ms)

“tₛ” ~ “transparency”  \quad tₛ = \frac{\int_{0}^{\infty} t \cdot p^2(\tau) d\tau}{\int_{0}^{\infty} p^2(\tau) d\tau}
Modeling of Small Rooms

Methods

Statistical: global, coarse approximation \(<\) small rooms

Numerical (FEM, BEM, etc.): elaborate, though computationally extensive (mesh resolution)

Geometrical acoustics:

easy to use and understand, but limited (low frequency, small rooms)

Chosen method: triangular beam-tracing (TBM)
Validation of TBM

- Comparison of measured and modeled data
  Parameters based on energy decay curves (EDC)

- Errors of the model
  Directional characteristics of source-receiver
  Incomplete knowledge of the properties of surfaces
  Limitations of TBM (geometry, diffusion, diffraction, etc.)

- Inverse validation
  Assumption: greatest error due to parameter errors
Inverse Calculations

- EDC fitting
- Measured EDC
- Modeled reflection timings
- Echogram amplitudes
  - carpet
- Absorption coefficients
Application of EDC fitting

Objective parameters define an “ideal” EDC

Calculating required parameters in the model

… distribution of absorptive and reflective surfaces

… directional characteristics of source-receiver

… possible errors of geometry
Application of EDC fitting - example

Design of shoebox for given $k_1$ and $T_{60}$
Conclusions

- New objective parameters
- Examining validity of modeling with TBM
- Design of EDC, based on the new parameters

Future...

- Other parameters (binaural?)
- Verification of EDC methods in practice
A1: Calculating absorption from echogram

\[
(1 - \alpha_1)^{M_{1,1}} \cdot (1 - \alpha_2)^{M_{1,2}} \cdots (1 - \alpha_N)^{M_{1,N}} = A_1
\]

\[
\vdots
\]

\[
(1 - \alpha_1)^{M_{K,1}} \cdot (1 - \alpha_2)^{M_{K,2}} \cdots (1 - \alpha_N)^{M_{K,N}} = A_K
\]

corrected amplitude of k-th reflection

absorption coeff. of n-th surface