Evaluation and Modeling of Small Rooms

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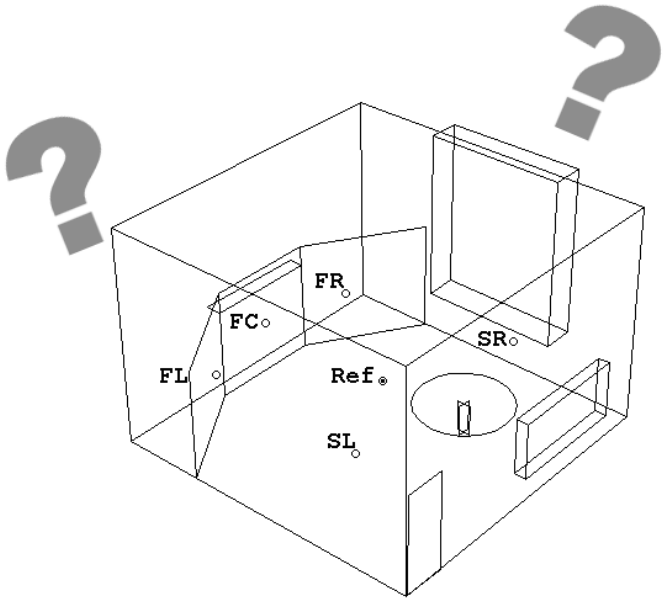


Contents

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
    measurements
    → correlations?
- Proposed objective parameters
  - … from measure impulse responses
  - … based on energy-time integrals

Objective Parameters that Correlated

- "k_1" or "k_2" ~ "stereo accuracy, spatial impression"

$$k_1(t) = \log_{10} \frac{\int_0^t p^2(\tau)d\tau}{\int_0^\infty p^2(\tau)d\tau} \qquad k_2(t) = \log_{10} \frac{\int_0^t p^2(\tau)d\tau}{\int_t^\infty p^2(\tau)d\tau}$$

- "M" ~ "timbre" $\qquad M = k_2(20ms) - k_2(5ms)$

- "t_S" ~ "transparency" $\qquad t_s = \dfrac{\int_0^\infty t \cdot p^2(\tau)d\tau}{\int_0^\infty p^2(\tau)d\tau}$

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

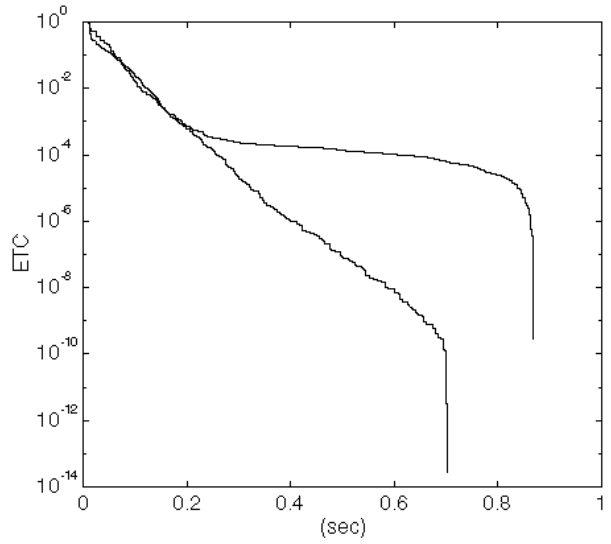
Measured EDC

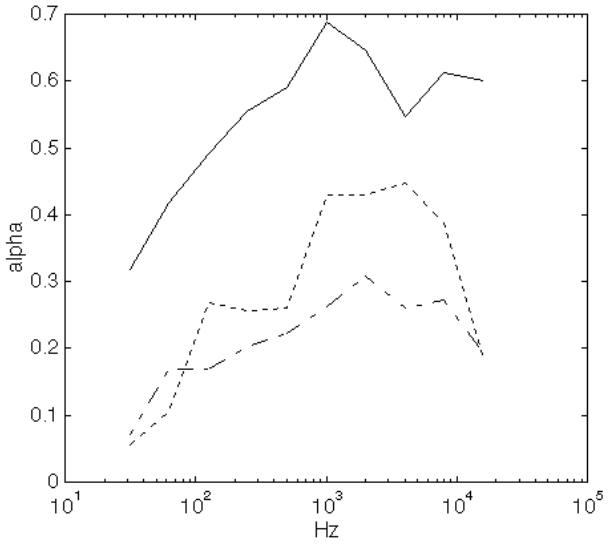
Modeled reflection timings

Echogram amplitudes

carpet

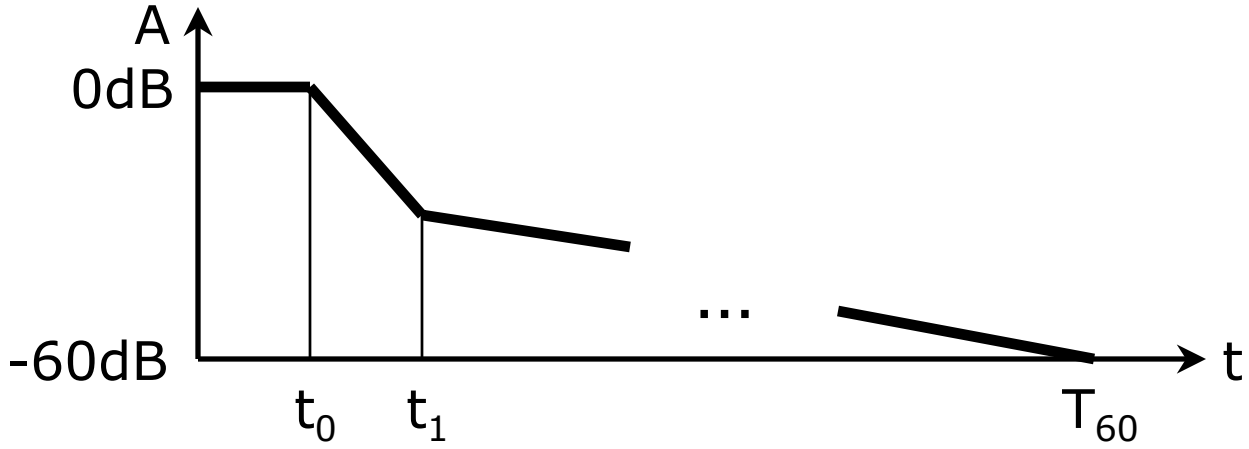
Absorption coefficients





Application of EDC fitting

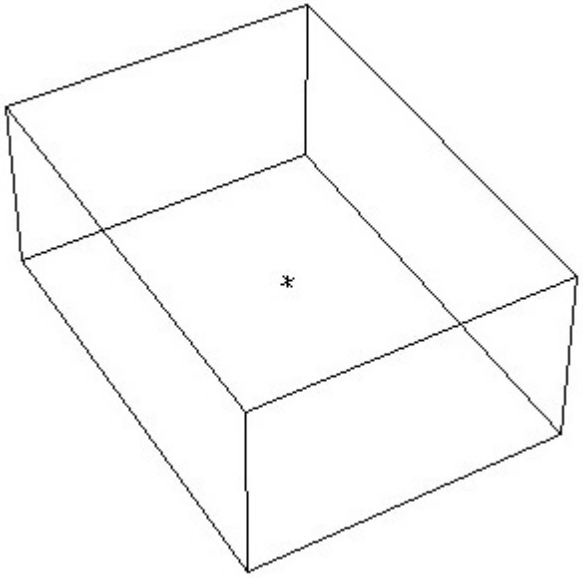
- Objective parameters define an “ideal” EDC

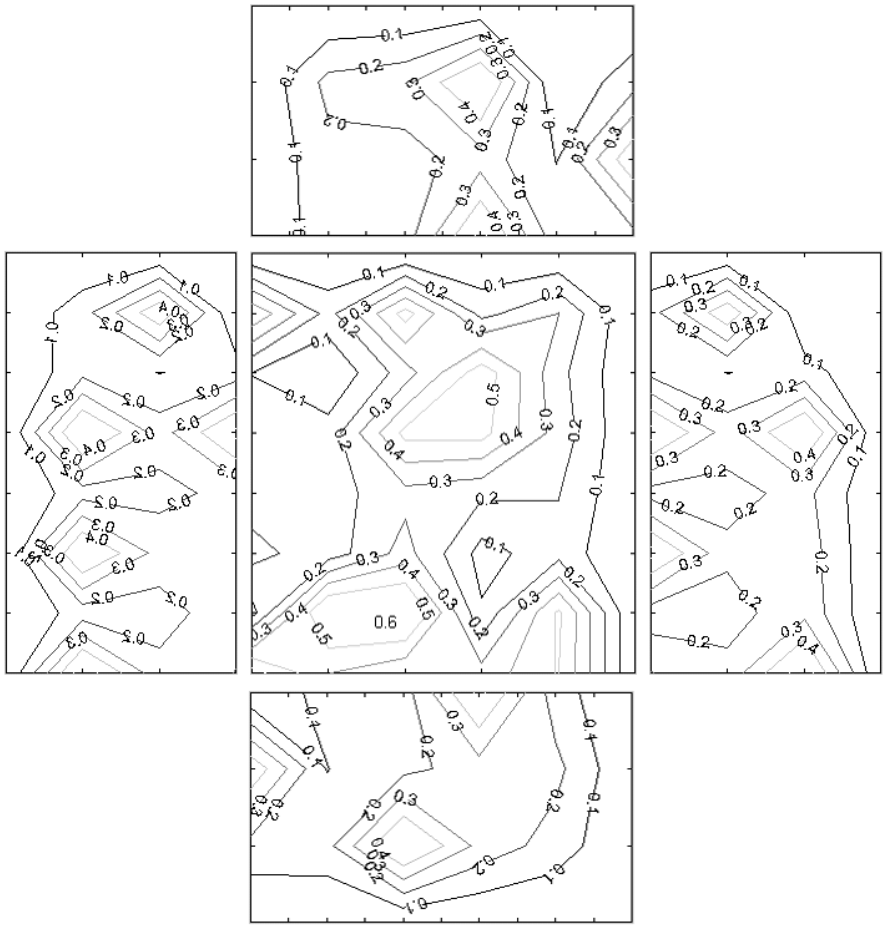


- Calculating required parameters in the model
  - … distribution of absorptive and reflective surfaces
  - … directional characteristics of source-receiver
  - … possible errors of geometry

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

$$\left(1-\alpha_1\right)^{M_{1,1}} \cdot \left(1-\alpha_2\right)^{M_{1,2}} \ldots \cdot \left(1-\alpha_N\right)^{M_{1,N}} = A_1$$

$$\vdots$$

$$\left(1-\alpha_1\right)^{M_{K,1}} \cdot \left(1-\alpha_2\right)^{M_{K,2}} \ldots \cdot \left(1-\alpha_N\right)^{M_{K,N}} = A_K$$

corrected amplitude of k-th reflection

absorption coeff. of n-th surface