AURALIAS

Intelsig

Real-time auralization:

a low cost updating of ray-tracing results induced by modifications of the acoustical space

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1. Background

- The Auralias project aims to create an immersive environment including sound rendering (auralization)

- Aims of the Auralias project:
  - interaction between the acoustician and the architect;
  - real time auralization.

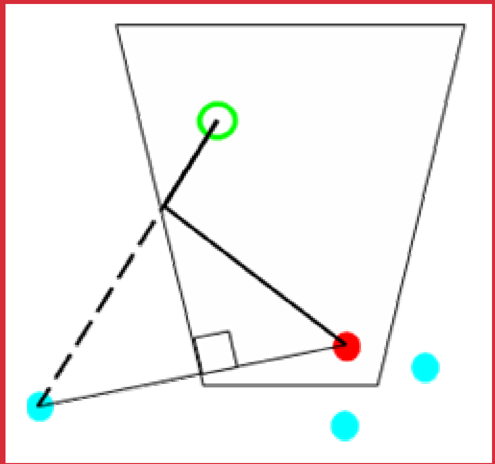
- Modifications of the room's acoustics:
  - absorption coefficient values;
  - diffusion coefficient values;
  - position of some sound reflectors.

→ Need to obtain the room's impulse responses (RIR) as quickly as possible.

1. Background

- RIR obtained through the geometrical room-acoutic program Salrev, developed at the ULg
- Salrev includes two prediction methods:

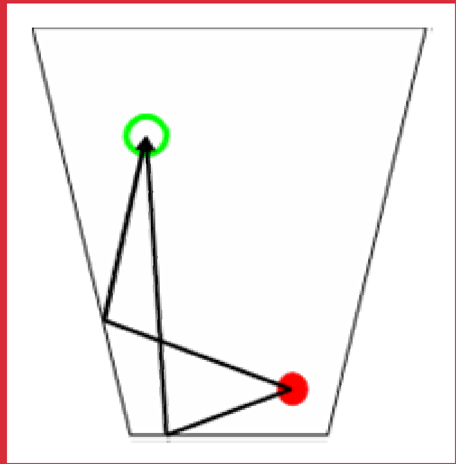
Mirror sources



First specular reflections

Very accurate directions

Ray-tracing



Diffuse reflections and late reverberation

More efficient for higher order reflections

1. Background

- Exact Room Impulse Responses:
  - calculation of the late part

→ Impraticable due to the long computation time (several minutes).

- Related work (Schröder & Assenbacher, 2008):
  - quick updating of the mirror sources;
  - recalculating the ray-tracing part.

→ No existing method suitable.

→ Necessity to develop our own method.

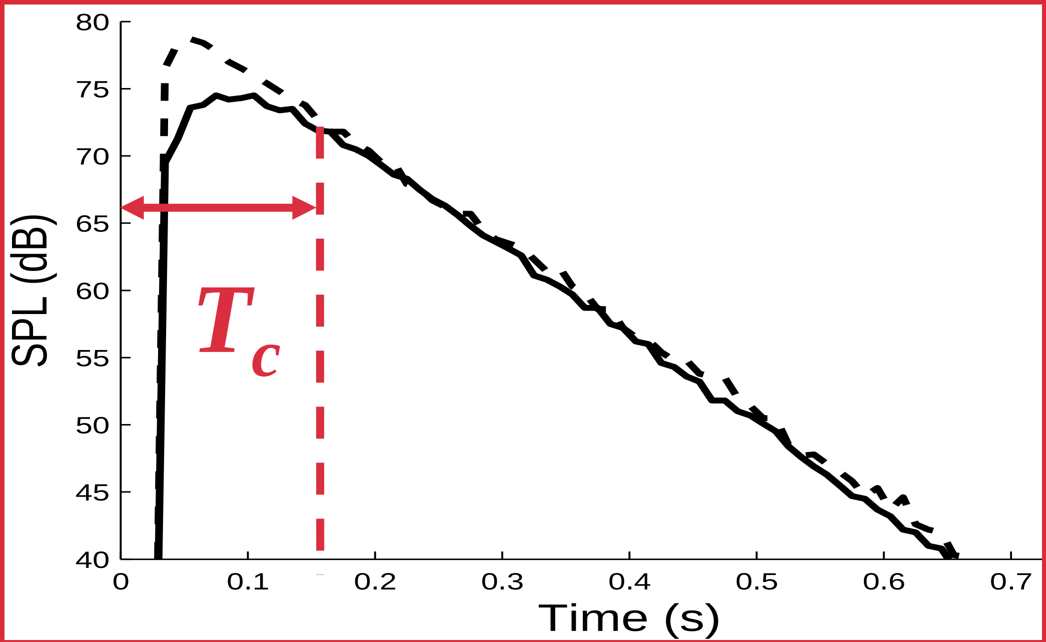
2. Main idea

- Minimising the computation load
- Dividing the echograms in 2 parts:

- the early part recalculated ($t<T_c$);

- the late part modelised ($t>T_c$);

- junction of the two obtained parts.



2. Main idea

- Minimising the computation load
- Dividing the echograms in 2 parts:

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  - junction of the two obtained parts.

- Updating the mirror sources
- Short time ray-tracing.
- Problems to solve:

  - value of the truncation time T_c;

  - modelling the late part.

4. Truncation time

- Physical criterion : mixing time T_m
  - $T_m \approx 2 \times \sqrt{V}$ in ms (Hidaka et al., 2007; Cremer & Müller, 1982);
  - $T_m \approx \sqrt{V}$ in ms (Defrance & Polack, 2008).

- Subjective criterion (Meesawat & Hammershoi, 2002)
  - not much sensitive to the sound decay >140 ms.

- Proposed law:
  - T_c=150 ms for V<5625 m^3;
  - T_c=2x$V^{1/2}$ ms for V>5625 m^3;
  - 150 ms = 50 m traveled by the sound.

5. Sound reflectors

- Hypothesis

The echograms' late parts are unaffected by the position or orientation of the sound reflectors.

- Method:

- modification of the reflectors positions;

- new ray launching for $t<T_c$;

- mirror sources updating;

- junction of the echograms at T_c.

6. Diffusion coefficient value

- Hypothesis

The echograms' late parts are unaffected by diffusion coefficient values:

- true for s>0,4 for all geometries;

- true for all s values for near cubic shapes.

- Method:

  - modification of the diffusion coefficients values;
  - new ray launching for $t<T_c$;
  - mirror sources power updating;
  - junction of the echograms at T_c.

7. Absorption coefficient value

- Hypothesis

The geometry owns a single mean free path value e.g. composed of a single enclosure.

- Method:

  - modification of the diffusion coefficients values;
  - new ray launching for $t<T_c$;
  - mirror sources power updating;
  - modelling of the late part;
  - junction of the echograms at T_c.

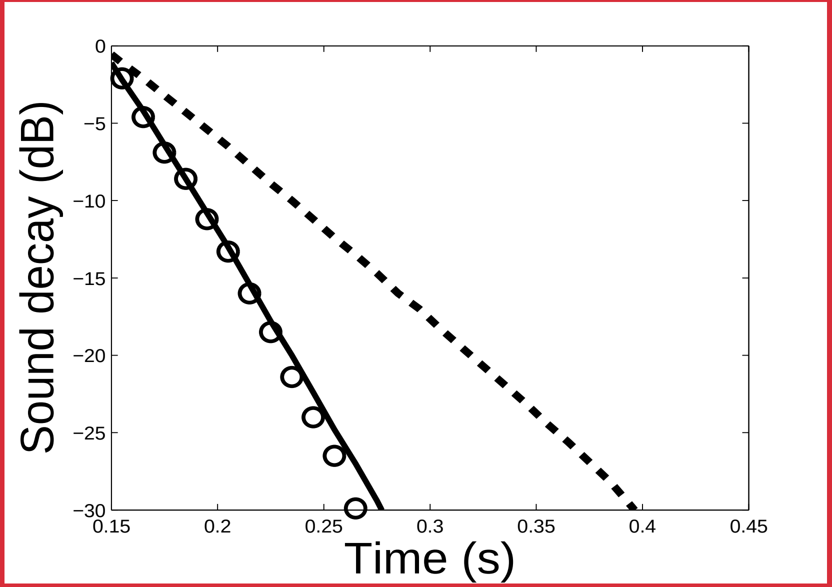
7. Absorption coefficient value

- Late part modeling based on statistical quantities

$$SPL'(t) \propto SPL(t)\frac{\ln\left(1-\overline{\alpha'}\right)}{\ln\left(1-\overline{\alpha}\right)}$$ with $$\overline{\alpha} = \sum_{i=1}^{n} p_i \alpha_i$$

where p_i is the probability of collision with surface i

- Example: Room 12x1x2 m^3



Ceiling absorption: 0.1 → 0.6
Other walls : 0.1

– – : Original echogram
o o : Aimed echogram
— : Modelised echogram

Very good agreement with the aimed echogram.

8. Conclusions

- Propositions allowing to speed up the updating of the echograms when the room acoustics is modified
- A truncation time based on objective and subjective criteria has been shown
- It allows to separate the echograms in two parts:
  - the early part which is recalculated;
  - the late part which can be approximated.
- Limitations:
  - deterministic phenomena: flutter echoes;
  - single volume when the absorption is modified.