Master's Dissertation at the Div. of Engineering Acoustics

AN OBJECTIVE MEASURE OF DETECTING STRONG REFLECTIONS IN ROOMS

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In this master thesis, the influence of a distinct and strong reflection on the impulse response will be investigated, together with the subjective experience of this phenomena.

Background

A strong reflections can arise due to unfavourable geometry of the room or lack of scattering at the walls. If the time delay compared with the direct sound of the source is larger than 50 ms, this can be perceived as an echo, i.e the reflection is perceived as a separate sound event. This is an unwanted effect since it may decrease speech intelligibility or distorts an sound played by musicians. A strong reflection results is a increase in the energy picked up by the receiver, compared to what should have been received if the room was diffuse. Furthermore, this increase in energy will appear as a sudden step in the energy decay curve. Therefore, the smoothness of the energy decay curve can be an indicator of strong reflections.

Purpose

The purpose of this thesis is to find a measure of the detection threshold of a strong reflection, using the instantaneous slope of the decay curve. This measure will then be compared with the existing measure by Dietsch and Kraak. The detection threshold will vary depending on delay-time, reverberation time and volume and these parameters should also be taken into account when finding the objective measure.

Method

Impulse responses are simulated under the assumption of a diffuse sound field using a statistical model. This results in a smooth decay curve which is free from strong reflections, and this is used as a reference response. Then, the reflection density is modified at a certain positions in time, in order to simulate a increase in energy at the receiver position, i.e a strong reflection. With this model, the properties of the room and the strength of the reflection are controlled variables, which makes it possible to investigate the influence of time-delay, reverberation time and volume on the detection threshold.

From the energy decay curve of the impulse response, the Slope Ratio can be found. This is the instantaneous slope normalized with the mean slope, which reveals sudden changes in the decay curve. Various properties of the Slope Ratio will be evaluated as a measure, and these are the maximum slope ratio and the size of the step in the energy density curve. These measures will then be compared with the criteria after Dietsch and Kraak. The objective measures will first be investigated to see their behaviour when increasing the strength of the strong reflection, and thereafter listening tests will be performed to find the detection thresholds.

The listening tests takes place in the listening booths at Center of Applied Hearing Research (CAHR) at the Technical University of Denmark. It will be performed for various delay times for the strong reflection relative the direct sound and different volumes and reverberation time. In order to ensure statistical significance, a minimum of eight test subjects will participate. The detection threshold is defined as the level at which 50% of the test subjects could hear the reflection.