

## 1. Room Impulse Responses

1. How can we measure a room impulse response?
2. What kind of test signal is necessary?
3. How does the length of the impulse response affect the length of the test signal?

## 2. First Reflections

For a given sound (voice sound) calculate the delay time of a single first reflection. Write a Matlab program for the following computations.

1. How do we have to choose this delay time? What coefficient should be used for it?
2. Write an algorithm which performs the convolution of the input mono signal with two impulse responses which simulate a reflection to the left output  $y_L(n)$  and a second reflection to the right output  $y_R(n)$ . Check the results by listening to the output sound.
3. Improve your algorithm to simulate two reflections which can be positioned to any angle inside the stereo mix.

## 3. Comb and All-pass Filters

### 3.1 Comb Filters

Based on the Schroeder Algorithm, draw a signal flow graph for a comb filter consisting of a single delay line of  $M$  samples with a feedback loop containing an attenuation gain  $g$

1. Derive the transfer function of the comb filter.
2. Now the attenuation gain  $g$  is in the feed-forward path and in the feedback loop no attenuation is applied. Why can we consider the impulse response of this model to be similar to the previous one?
3. In both cases how should we have to choose the gain factor? What will happen if we do not respect that?
4. Calculate the reverberation time of the comb filter for  $f_s = 44.1$  kHz,  $M = 8$  and  $g$  specified previously?
5. State about the filter coefficients, plot the pole/zero locations and the frequency response of the filter.

## 3.2 All-pass Filters

Realize an All-pass structure as suggested by Schroeder.

1. Why can we expect better result with All-pass filter than with comb filter? Write a Matlab function for a comb and all-pass filter with  $M = 8, 16$ .
2. Derive the transfer function and show the pole/zero locations, the impulse response, the magnitude and phase responses.
3. Perform the filtering of an audio signal with the two filters and estimate the delay length  $M$ , which leads to a perception of a room impression.

## 4. Feedback Delay Networks

Write a Matlab program which realizes a feedback delay network.

1. What is the reason for a unitary feedback matrix?
2. What is the advantage of using a unitary circulant feedback matrix?
3. How do you control the reverberation time?