EE229: Signal Processing I

Practical Assignment 1

Virtual Reality with Convolution

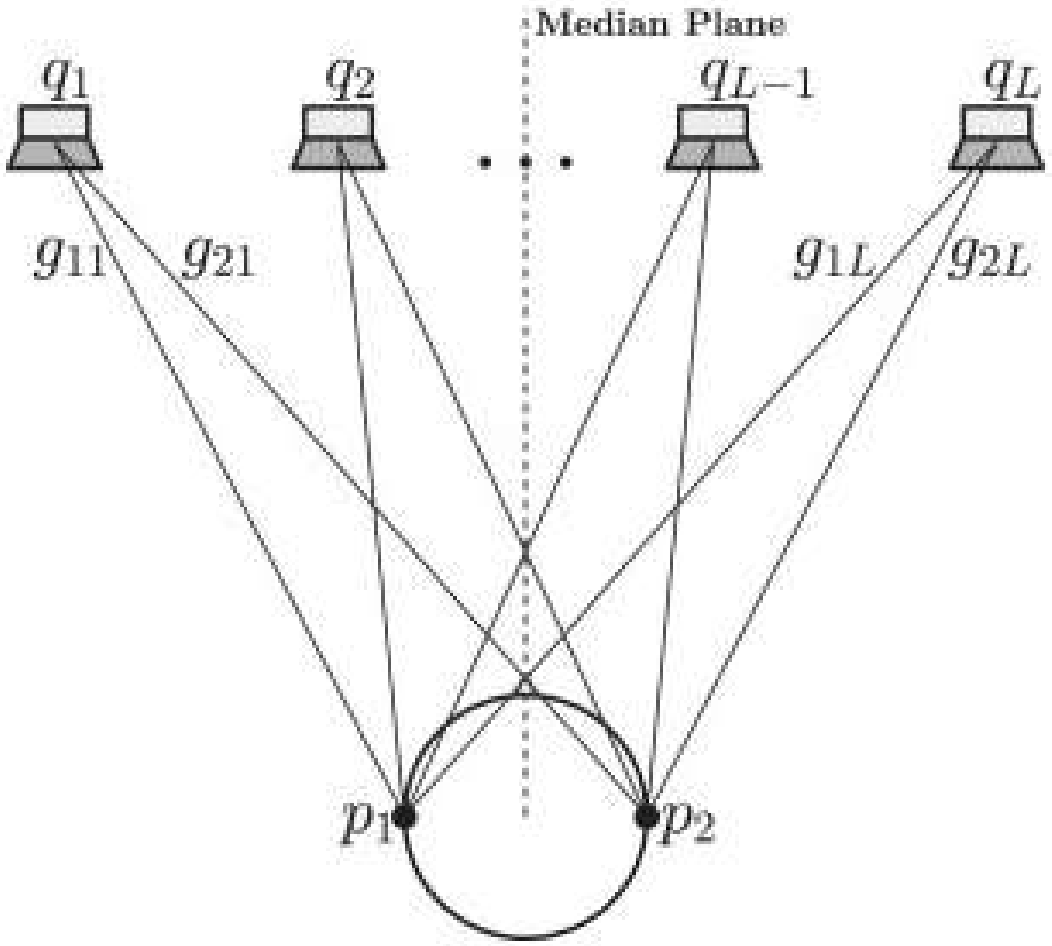
Audio processing for Virtual Reality

- To be able to create an “immersive” experience for the remote listener.

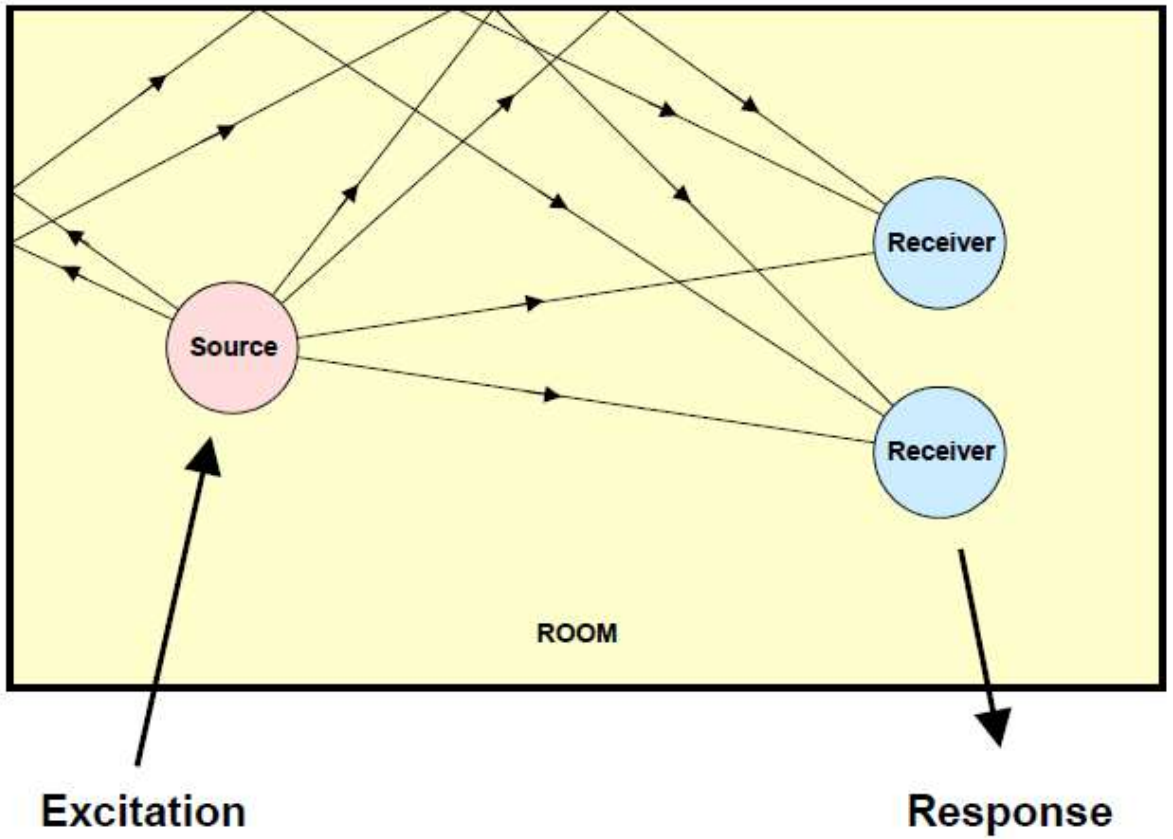
I.e. perceiving a source in its specific location in a specific environment. We need cues to (i) source location (ii) cues to the surrounding environment.

- There are two different methods of surround sound simulation. The first one uses numerous loudspeakers placed around a room. The second one uses *stereophonic headphones.*

Cues to sound source location



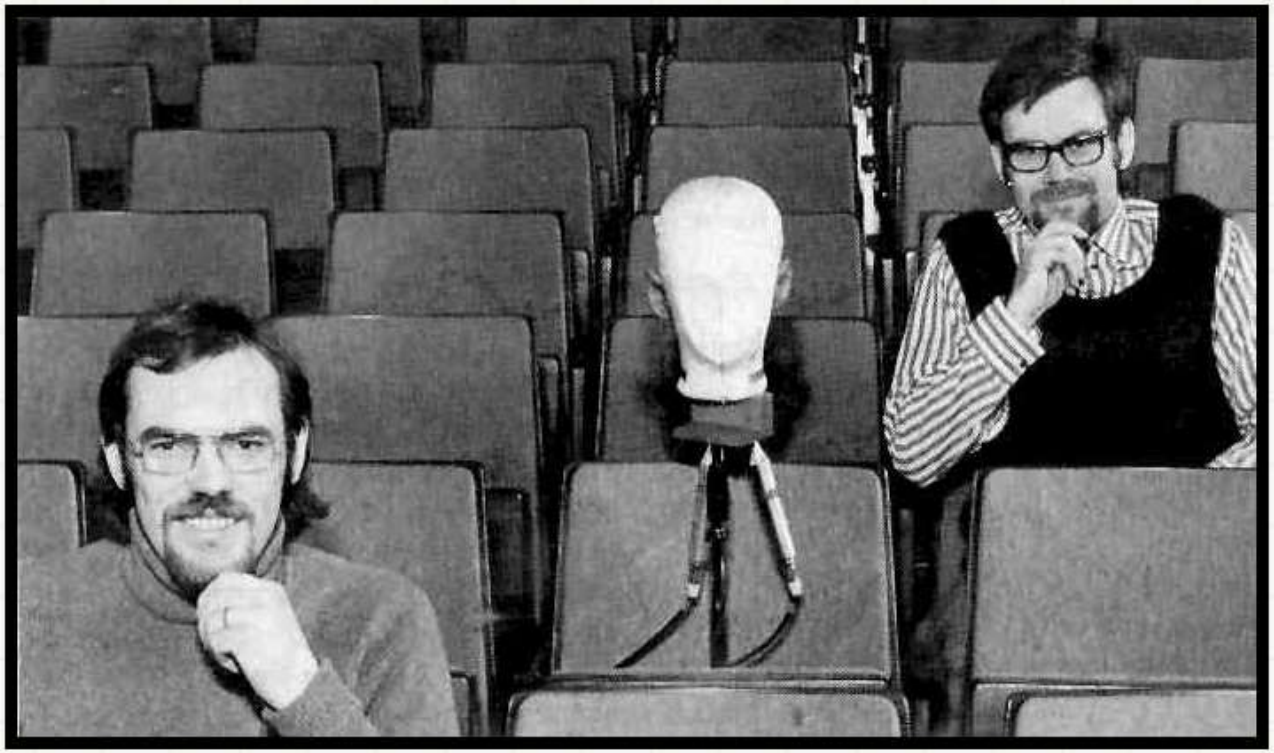
Cues to the source-listener environment



Ensemble recording in the NDR radio concert hall; Cortex dummy head at the right side

So how do we create the “immersive experience” for a remote listener?

The Sound of Music

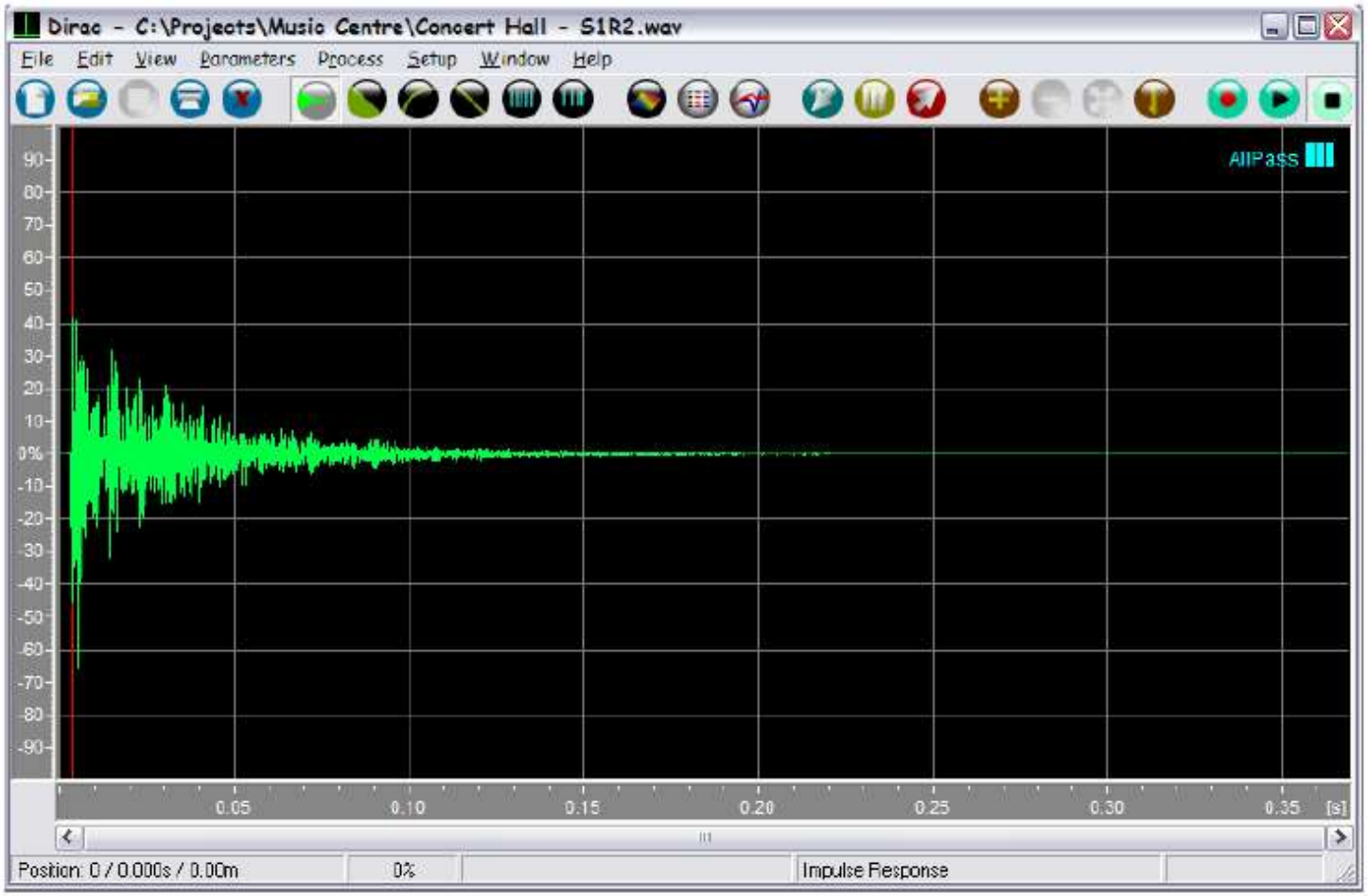


Manfred Schroeder's collaborators K F Siebrasse (left) and D Gottlob (right) and the dummy head through which they recorded the sounds of 20 European concert halls.

How about modeling?

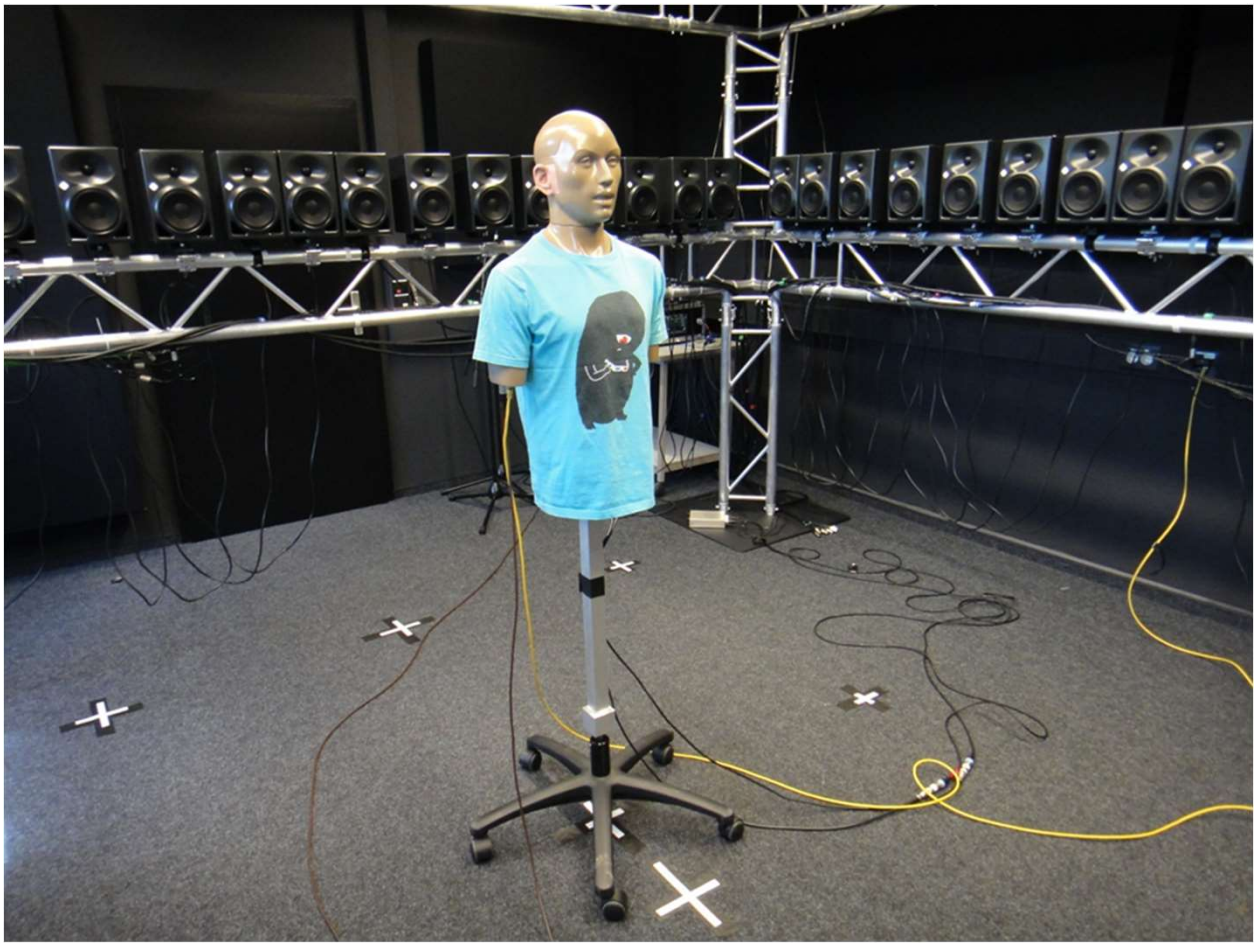
- Our physical system takes the source-emitted sound signal as input and outputs the left- and right-ear received signals.
- Modeling the physical system would allow us to recreate the experience for a remote listener with *any* source signal.
- Physical modeling needs details of room dimensions and physical characteristics of walls, etc.
- An attractive option for the (assumed LTI) system is…

Impulse source to left-ear response in a hall

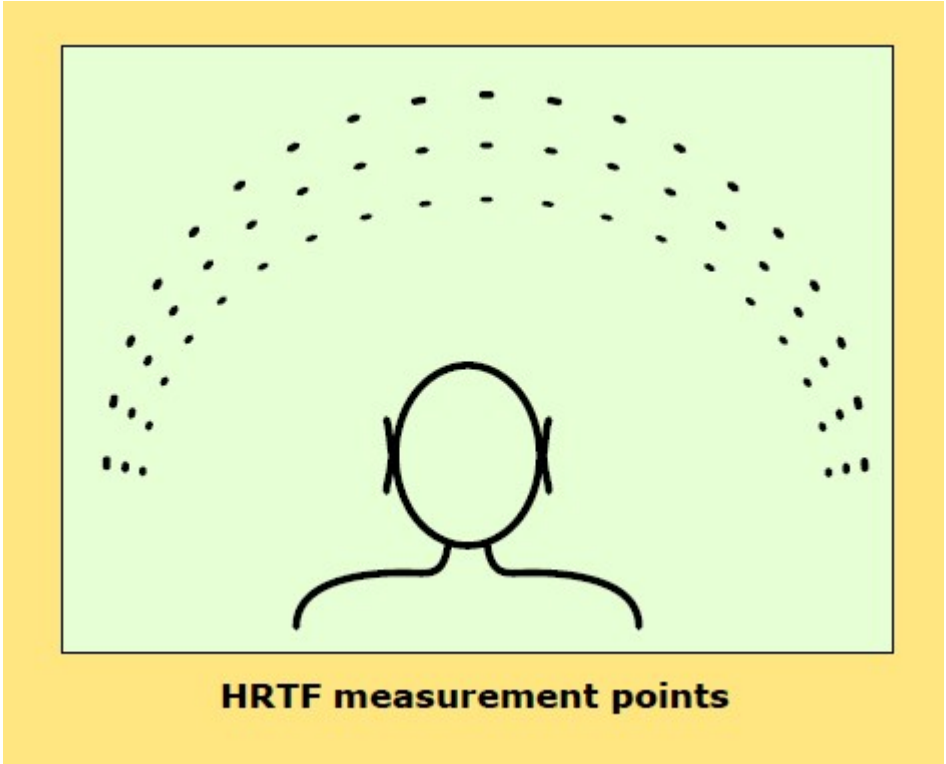


Attenuated, delayed responses from reflections

Impulse response measurement: BRIRs



http://spatialaudio.net/free-database-of-single-channel-and-binaural-room-impulse-responses-of-a-64-channel-loudspeaker-array-for-different-room-con%EF%AC%81gurations/



HRTF measurement points

Binaural room impulse response (BRIR) databases

http://www.voxengo.com/impulses/

http://recherche.ircam.fr/equipes/salles/listen/index.html

http://www.iks.rwth-aachen.de/en/research/tools-downloads/aachen-impulse-response-database/

Computing assignment

- Provided are: an audio signal (part of a solo song), 3 different BRIR (2-channel impulse responses) from different “rooms” and fixed source-listener configuration.

- Use convolution to obtain binaural signals that you can listen to over headphones.
- Code fragments provided for Scilab.

Toy Problem

- To understand the convolution process and its implementation, please write code for the following convolution: $x[n] * h[n]$, where $x[n] = \alpha^n u[n]$ and $h[n] = u[n]$. Evaluate the convolution for $n = 0, 1, \cdots, 10$, for $\alpha = 0.4$.

- Write the convolution code using basic addition, multiplication and for loops.

- Compute the closed form expression for $y[n] = x[n] * h[n]$ for $n = 0, 1, \cdots, 10$, and verify that your code output matches these values.