AURA3D – An Ambisonics System at ESML

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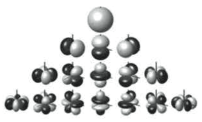
Objectives: **Implement a 3rd order Ambisonics System in a reverberant space**

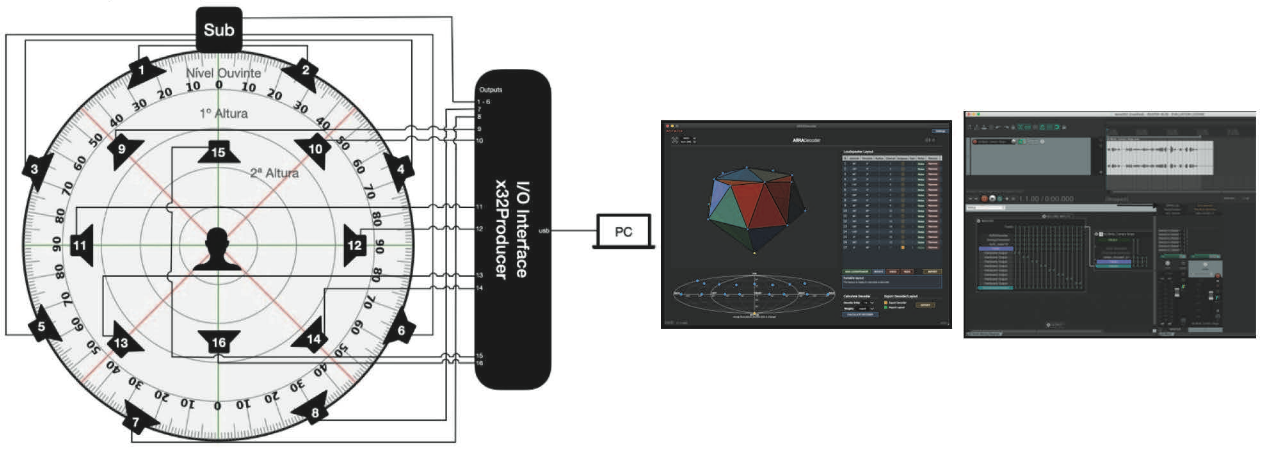
Difficulties: **Determination of the inverse dereverberation filters for the 16 channels of the Ambisonics System**

Approach: **32 room impulse responses measured (2 for each channel), complex smoothed, and the 16 dereverberation filters are developed through a multiple-input, multiple-output inverse theorem method (MINT)**

AURA3D 3rd Order Ambisonics System

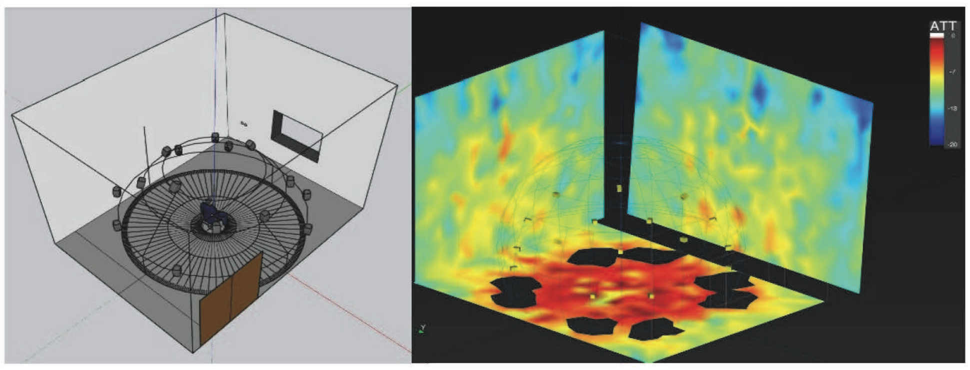


- Regular hemispherical arrangement (ca. 5 metres diameter)
- Lower ring speakers: 8 x Tannoy Gold 7 concentric active monitors
- Middle ring speakers: 6 x Genelec 8040 fullrange active monitors
- Upper ring speakers (VOG): 2 x Genelec 8040 fullrange active monitors
- Subwoofer Genelec 7350
- All-Round Ambisonics Decoding (AllRAD)
- USB I/O Behringer x32 Producer



AURA3D System schematics

Photograph of the AURA3D System

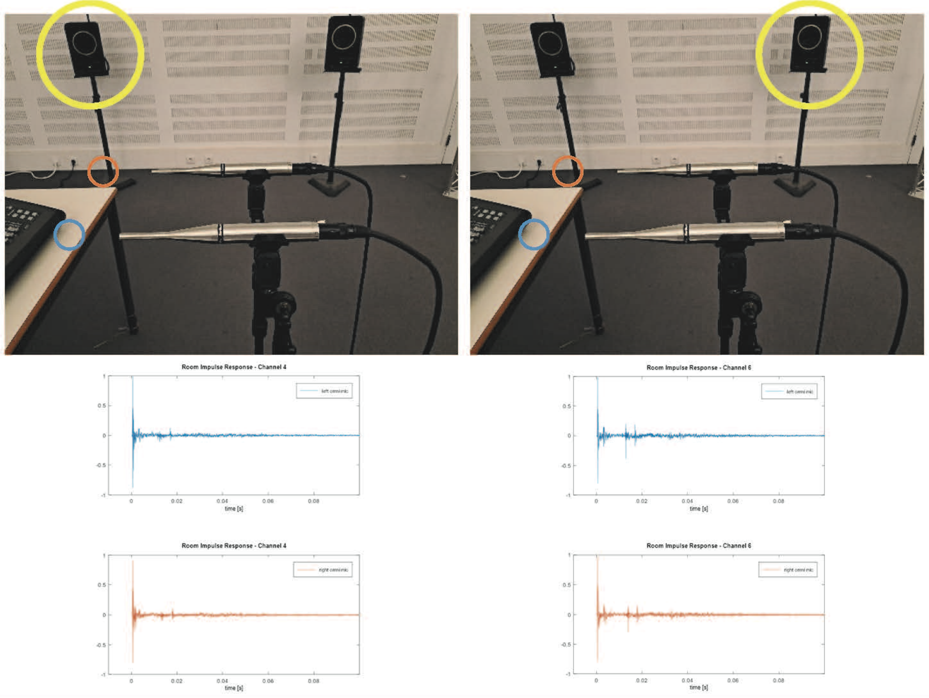


AURA3D System Simulation in Mapp3D

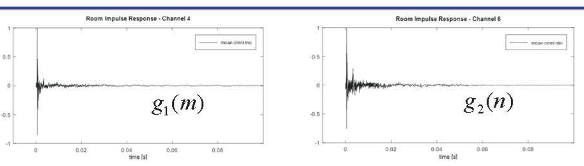
AURA3D 16 channels dereverberation filters

STEP 1: For each individually operated channel: RIRs measured for a stereo omni set (measurement mics Earthworks M30)

Example: channel 4 Example: channel 6



STEP 2: 1/24 oct. complex smoothing + left right averaging

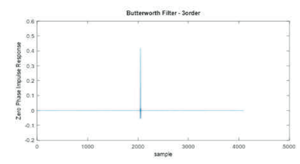


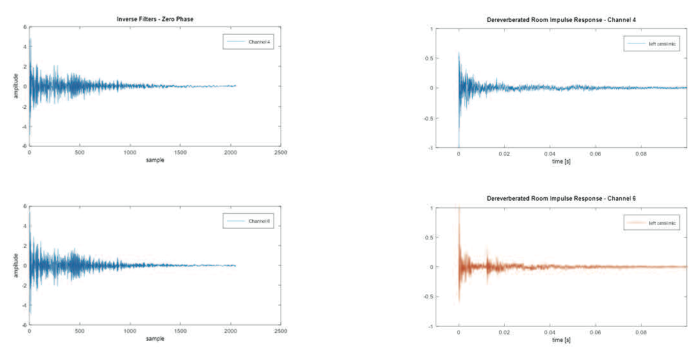
STEP 3: multiple-input, multiple-output inverse theorem method (MINT)

$$D=[G_1\ G_2]\begin{bmatrix}H_1\\H_2\end{bmatrix}\Leftrightarrow \underset{L+1}{\begin{bmatrix}1\\0\\0\\.\\.\\.\\.\\.\\.\\.\\0\end{bmatrix}}=\begin{bmatrix}g_1(0) & & g_2(0) & \\ g_1(1) & 0 & g_2(1) & 0\\ . & & . & \\ . & & . & \\ & g_1(0) & g_2(n) & \\ g_1(m) & g_1(1) & & g_2(0)\\ & . & & g_2(1)\\ & . & & .\\ 0 & . & 0 & .\\ & . & & .\\ & g_1(m) & & g_2(n)\end{bmatrix}\begin{bmatrix}h_1(0)\\h_1(1)\\.\\.\\h_1(i)\\h_2(0)\\h_2(1)\\.\\.\\.\\h_2(j)\end{bmatrix}\Rightarrow\begin{bmatrix}H_1\\H_2\end{bmatrix}=[G_1\ G_2]^{-1}D$$

$\leftarrow\ i+1\ \rightarrow\ \leftarrow\ j+1\ \rightarrow$

D – desired IR for band pass filter: 65 - 20000 Hz (Tannoy Gold 7); 45 - 20000 Hz (Genelec 8040)





Conclusions: **A 3rd order Ambisonics System was successfully implemented resorting to 16 suitable dereverberation filters that were designed from measured impulse responses and through the multiple-input, multiple-output inverse theorem method (MINT). 3D auralizations were performed and preliminary listening tests were conducted. These tests show that the AURA3D System is working as intended with a very good spatialization of sound and without noticeable colorations. Future work will consider the optimization of the dereverberation filters and additional listening tests.**

References:

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[2] Hirofumi, N.; Miyoshi, M.; Tohyama, M. *Sound field control by indefinite MINT filters*. IEICE Trans. Fundam. Electron. Commun. Comput. Sci. 1997, 80, 821–824

[3] Nelson, P.; Orduna-Bustamante, F.; Hamada, H. *Inverse filter design and equalization zones in multichannel sound reproduction*. IEEE Trans. Speech Audio Process. 1995, 3, 185–192

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