Experimental Research Lab: Introducing a Real and Virtual Goniometer

Thus far we have been describing a boundary plane goniometer that can be set up in a convenient, reverberant space to measure the polar scattering and diffusion coefficient. ISO 17497-2 also provides a measurement procedure for a 3D goniometer in an anechoic environment. In this post, we will compare the experimental measurements for a square-based pyramid sample in a 2D goniometer in a reverberant field and a 3D goniometer in an anechoic chamber with a simulation, using a new, virtual 3D goniometer called Virgo from a 3D CAD file. We will then leave the Experimental Research Lab and enter the Virtual Simulation Lab!

In Figure 1, we show a 2D boundary plane goniometer in the RPG ARC vertically mounted and a 3D goniometer in an anechoic chamber. The new 2D goniometer is vertically mounted in a reverberant space. The five source speakers are all mounted in place at a 30°, 60°, 90°, 120°, and 150°, as specified in ISO 17497-2. A 32-micophone array is flush mounted and not visible in the image. A white-dashed line is added to locate the mic radius. The face of the test sample is mounted flush with the white “T.” Absorption is added on the ceiling, below the platform, and on the floor to minimize interfering room reflections. The procedure to isolate the scattered sound is described in DR 220519.

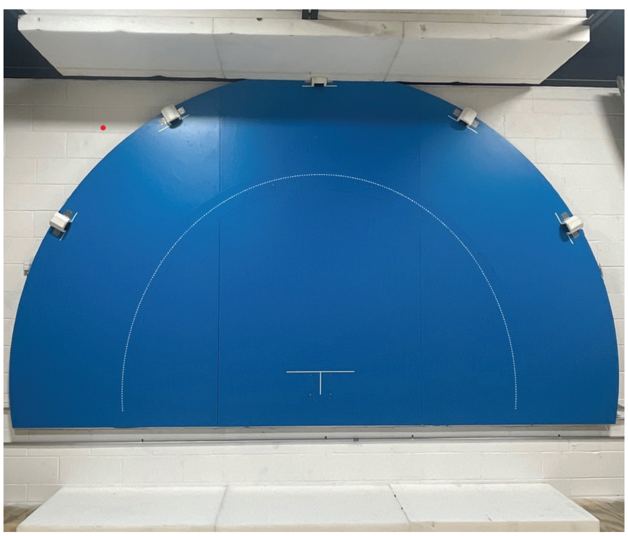

Figure 1. Left: 2D boundary plane goniometer; Right: 3D goniometer in an anechoic chamber

Can the diffusion coefficient be simulated?

In an effort to develop a 3D diffusion coefficient simulation program, we re-examined data collected in 1998 at Salford University (*Hargreaves TJ, Cox TJ, and Y.W. Lam YW, D’Antonio P., Surface diffusion coefficients for room acoustics: Free-field measures. J Acoust Soc Am. 2000; 108:1710-20).* In Figure 2 (left), we show the 13 specified positions for the source loudspeaker according to ISO 17497-2 and a schematic illustration of a 3D goniometer. Figure 2 (right), shows two concentric hemispherical arcs, which are capable of being rotated about the vertical axis. The inner arc contains 37 microphones separated by 5° and the outer arc contains the speaker, which can assume the 13 angles of elevation and azimuth. Figure 1 (right) shows the actual 3D goniometer in an anechoic chamber. A red sample is located at the origin.

Position number	Elevation θ	Azimuth ϕ
1	**0**	**-**
2	30	0
3	30	60
4	30	120
5	30	180
6	30	240
7	30	300
8	**60**	**0**
9	60	60
10	**60**	**120**
11	60	180
12	**60**	**240**
13	60	300

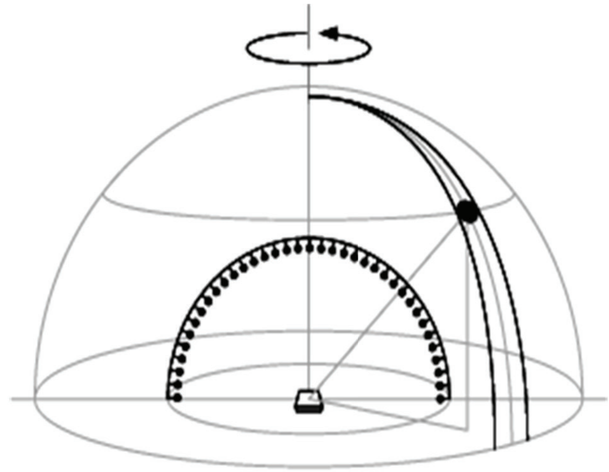

Figure 2. Left: ISO 17497-2 loudspeaker positions; Right: 3D schematic goniometer showing sample, microphone, and speaker arcs.

For an asymmetric sample, the measurement requires 936 (360/5x13) measurements, i.e., 72 measurements with the microphone arc rotated with 5° increments for each of the 13 speaker positions. There are 37 (180/5+1) microphones on the microphone arc with an angular spacing of 5°. This yields 34,632 (936 x 37 microphones) impulse responses. The measurements take 4-5 hours and suggest the need for a numerical simulation.

The 2D and 3D measurements were conducted according to ISO 17497-2. The polar responses and diffusion coefficients were also simulated with a boundary element virtual goniometer program called Virgo. A comparison of the normal incidence, 2 kHz polar responses for a square-based pyramid are shown in Figure 3. The agreement between the measured and simulated responses prove that the diffusion coefficient could be accurately numerically simulated.

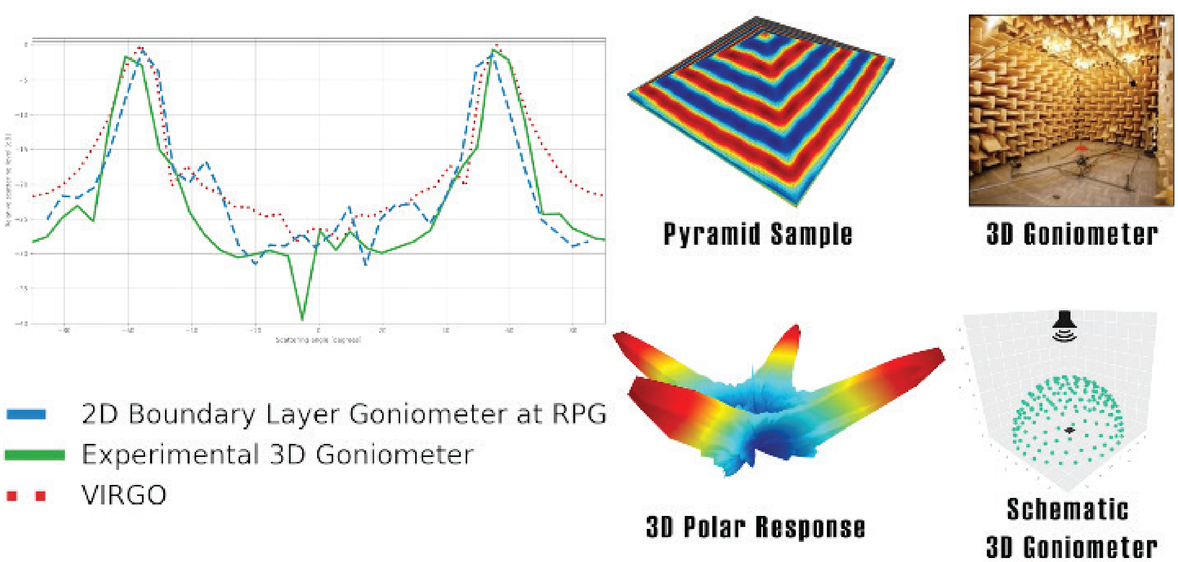

Figure 3. Comparison between the 2D and 3D goniometer normal incidence 2 kHz polar responses measured according to ISO 17497-2 and the simulated response from Virgo.

In the next post, we will leave the Experimental Research Lab and enter the **Virtual Simulation Lab**, where we will describe th enew, wave-based BEM virtual goniometer program, called VIRGO, which will be used to predict the diffusion and scattering coefficients of any shaped surface from a 3D CAD file. This significantly reduced measurement time, eliminates the need to make prototypes and can be conducted in the near or far field.

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