Virtual Education Lab: Introducing the Shape Optimization System (SOS)

Having described the evolution of the reflection phase grating diffusor, we begin a new syllabus on the optimization of curvilinear architectural acoustic shapes, which may be more aesthetically acceptable in architectural spaces.

The most common and enduring components of classic or classically inspired architecture are the beautiful statuary, relief ornamentation, columns, and coffered ceilings. These beautiful features coincidentally also provided useful sound scattering. This is evident in three of the renowned concert halls, namely the Concertgebouw in Amsterdam, the Musikvereinsaal in Vienna and Boston Symphony. More modern rectilinear architecture, which is devoid of this ornamentation, does not offer the same useful sound scattering. However, it is possible to acoustically optimize modern curvilinear surfaces to complement contemporary architecture, the way that the aforementioned surfaces complemented classic architecture.

Many acoustical products are created with a form follows function aesthetic and architects can often find it difficult to integrate them into their designs. In order to maintain a given design motif, but optimize its scattering properties, two new software approaches are now available as part of the Shape Optimization System (SOS); VIRGO and the Shape Optimizer.

Step 1: VIRGO (https://doi.org/10.1121/2.0001645)

In past posts, we described a virtual goniometer program, called VIRGO, which can evaluate the scattering properties of a shape from a 3D CAD file. No longer do we need physical scale model prototypes for testing. An architectural acoustic design team can now quickly evaluate the scattering properties of potential aesthetic shapes. A test performance report is shown in Figure 1. In addition, VIRGO also provides 3D animated polar responses at various angles of incidence and frequency for more detailed analysis. More on this in later posts. At the top of the report are descriptions of the analysis and an illustration of the 3D goniometer, showing the 4,295 receiver positions and the 13 source positions specified in ISO 17497-2. Below that is a drawing of the sample being evaluated and the diffusion and normalized diffusion coefficients. Below that are 3D polar responses for four sample angles of incidence at 5 octave band frequencies,

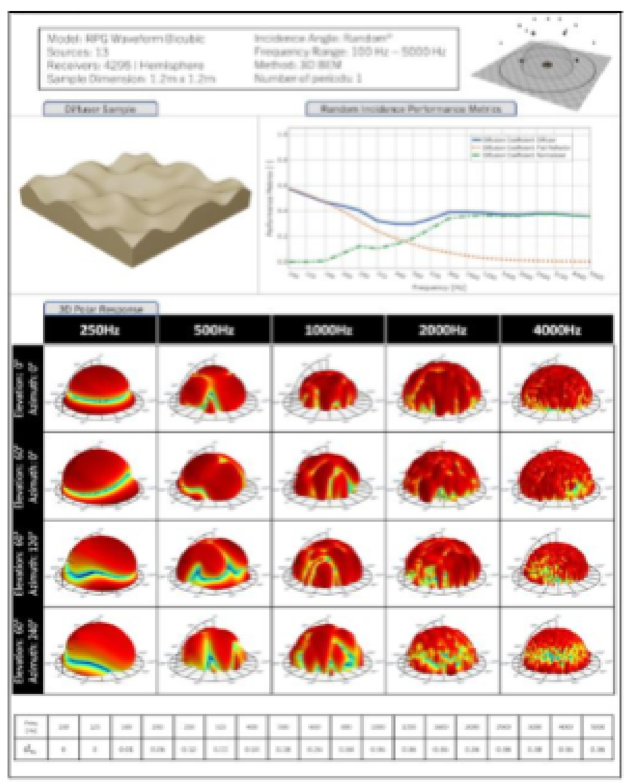

Figure . The VIRGO performance repost

followed by the normalized diffusion coefficients.

Step 2: Shape Optimizer
If the aesthetic design provides satisfactory performance, this analysis quickly moves the project forward. If the performance in not satisfactory, we then utilize the Shape Optimizer, which is a wave-based software program that acoustically optimizes the shape, while maintaining the desired motif as a constraint.

The Shape Optimizer allows the architect to propose a shape motif, e.g., a sinusoidal surface. Then, this surface is mathematically described, and the program evaluates, in an iterative manner, the hundreds or more possible perturbations of this shape, which provide the desired sound scattering. To accomplish this, three things are needed. An accurate prediction method, a metric to evaluate performance and an intelligent search engine, which can quickly and efficiently navigate through the myriad shape possibilities. A workflow diagram of the Shape Optimizer is shown in Figure 2, with *static* images of a step and a curvilinear optimization. The prediction method utilized is an accurate Boundary Element Method; the performance is monitored with a standardized metric called the diffusion coefficient (ISO 17497-2), which characterizes how uniformly sound is scattered; and the downhill simplex intelligent search engine. The iterative optimization continues until a satisfactory diffusion coefficient is found.

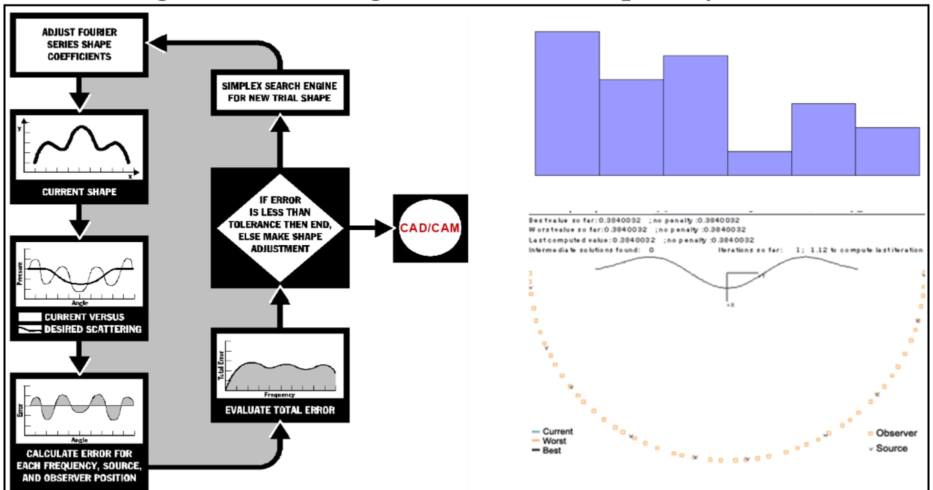

Figure 2. Shape Optimizer workflow and example animations of a block height design and the curvilinear optimization.

In the next post, we will describe the iterative Shape Optimizer in more detail.

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