Acoustical Optimization of Modern Architectural Spaces

by

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An enduring characteristic of classic architecture is the beautiful statuary, relief ornamentation, columns and coffered ceilings. These beautiful features, coincidentally also provided useful sound scattering and excellent acoustics. This is evident in three of the renowned concert halls, namely the Concertgebouw in Amsterdam, the Musikvereinsaal in Vienna and Boston Sym-

Figure 1. Musikvereinsaal concert hall showing various forms or ornamentation leading to good sound diffusion.

phony. Typically modern architecture lacks this intricate detailing and has evolved through a rectilinear era and is currently in a curvilinear or amorphous era. The acoustic fallout of these missing scattering elements is that modern rooms do not have good sound diffusion. What is needed are surfaces that complement contemporary architecture, the way that ornamentation complemented classic architecture.

Most readers will be familiar with aurally disfunctional rooms, like shopping malls or airports, where you can't understand announcements or school auditoriums and some performance venues, where music sounds terrible. Properly designed rooms need acoustic treatments on the

Figure 2. Optimized ceiling at Cinerama in Seattle, WA. The optimized ceiling provided an outerworldly shape with fiber optic lighting to enhance the digital projection sound.

walls, floor and ceiling to make speech intelligible and music beautiful.

In order to generate these modern sound diffusing surfaces, a software program called the Shape Optimizer was developed. The goal is es-

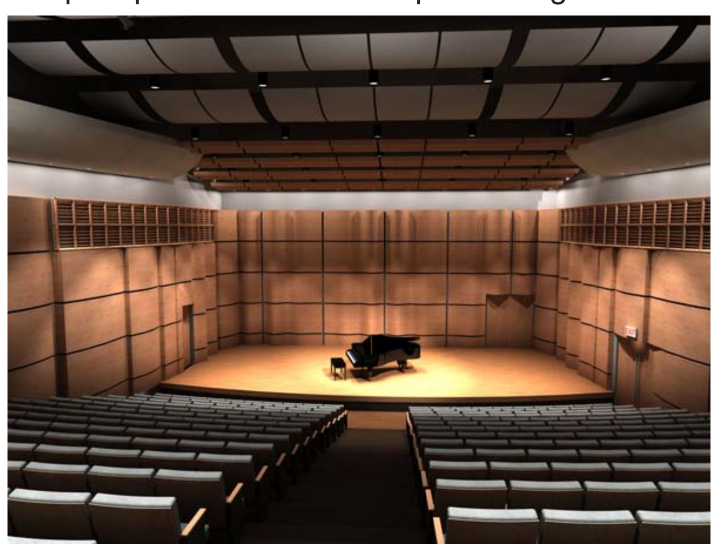

Figure 3. Optimized curvilinear wooden shapes on the walls and ceiling of the College of St. Rose, Massry Arts Center, Albany, NY. Rendering by Saratoga Architects.

sentially reverse engineering. Many acoustical products are created as a form follows function

Figure 4. Collage of images at the Thomas Deacon Academy in Peterborough, UK. Upper left and right: Ceiling mounted optimized spline in glass reinforced gypsum; Center: Outside photo: Lower left: Lecture hall optimized wavy rear wall; Lower right: Close up of the optimized wavy wall to minimize focusing effects.

and architects have to find a way to integrate them into their designs. 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 thousands or more possible perturbations of this shape, which provide the desired sound scattering, so the architect gets the visual aesthetic they desire, while the acoustic consultant gets the best possible sonic performance.

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. The prediction method utilized is a very accurate Boundary Element Method; the performance is monitored with a recently standardized metric called the diffusion coefficient, which characterizes how uniformly sound is scattered; and the intelligent search engine can be either a downhill simplex, which if you were in a mountain range quickly finds the lowest valley or a genetic algorithm, which is similar to human genetics in which the fittest shape survives. Since current architecture is leaning towards curvilinear forms, we will present three examples, which were treated with this type of shape.

The first is a commercial theater called Cinerama in Seattle. The architect wanted an outer-worldly undulating ceiling for this state-of-the-art digital projection cinema. The final design and installation is shown in Figure 2. The architect was Boora Architects, Portland, OR and the acoustician was Harris-Grant Associates, Guilford, UK.

The second example involves a performance hall at the College of St. Rose, Albany, NY in which the architect and acoustician requested curved wood shapes on both the walls and ceiling. This can be seen in Figure 3. The architect was Saratoga Architects, Saratoga Springs, NY and the acoustician was AVL Designs, Penfield, NY.

A third example is the Thomas Deacon Academy in Peterborough, UK, shown in Figure 4. This is a very modern Sir Norman Foster design as can be seen from the exterior of the building, shown in the center of the photo collage. The Shape Optimizer was used to determine a curvilinear ceiling shape, shown upper left and right, as well as an amplitude modulated rear wall in the Lecture Hall, which mitigated the focusing effect of the concave rear wall. These shapes were intended to mimic the curvilinear shape of the building's exterior. The acoustician was Harris-Grant Associates, Guilford, UK.

This optimization approach, along with a thorough treatment of all that is currently known about sound absorbing and sound diffusing surfaces is presented in a reference text by the authors entitled "Acoustic Absorbers and Diffusers: Theory, Design and Application, 2n Edition, Taylor & Francis 2009".