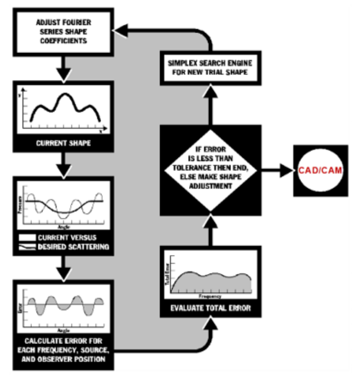
Virtual Education Lab: Shape Optimizer Details

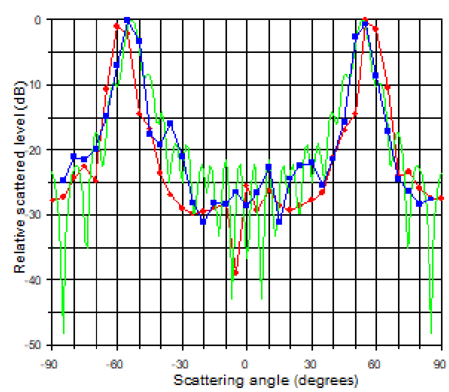
In the last post we introduced the Shape Optimizer System (SOS) consisting of VIRGO and the Shape Optimizer software. In this post, we describe the Shape Optimizer iterative flow chart in greater detail. Below we describe steps that are used to iteratively search for an optimal shape, which maintains the original aesthetic motif, but also provides the desired acoustical performance. A more thorough description can be found in my book with Prof. Trevor Cox entitled, “Acoustic Absorbers and Diffusers: Theory, Design and Application,” 3rd Edition, CRC Press (2017). 5



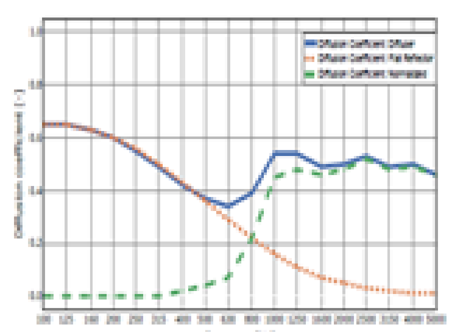
1.The surface is mathematically described by a Fourier series, a cubic/bicubic spline or a fractal. Using a 1-dimensional Fourier series, we can represent the surface displacement, y, as shown. a_n and b_n are the shape parameters that are altered to change the shape, k_x is usually set so that the first harmonic corresponds to half a wavelength across the panel in the x direction and N is the number of harmonics used.

$$y(x) = \sum_{n=1}^{N} a_n \cos(k_x x) + b_n \sin(k_x x).$$

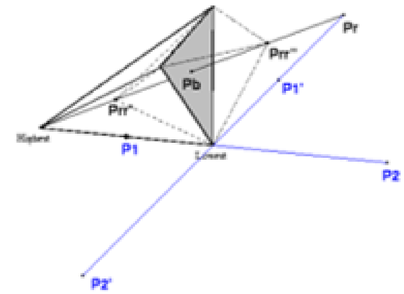
2. The scattered pressure is calculated at the receivers from all sources, using the Kirchhoff boundary condition to the wave equation. This formulation has been verified with comparisons to many experimental measurements. A comparison with a square based pyramid is shown to the right.



3.The diffusion coefficient is used as a performance metric for uniform scattering. The graph illustrates both the diffusion coefficient (solid blue) and the normalized diffusion coefficient (dashed green line), which corrects for edge diffraction, by normalizing with the diffusion coefficient of a flat panel of similar size (red dots).



4. The shape parameters are adjusted in an iterative process until the desired performance is achieved, using an efficient search engine, like the downhill simplex or a genetic algorithm, to search through the myriad shape possibilities.



5. The optimized shape is output as a CAD file for manufacturing or further testing.

The Shape Optimizer can be used to optimize a modulated array of 1D curvilinear shapes, including a surface profile, a stage shell and ceiling clouds, audience clouds and an amplitude modulated concave arc. In the next post, we begin with a description and example of an optimized 1D modulated wall mounted curvilinear surface profile array.

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