diffuse Bulletin

RPG Continuing Education Series

Volume 1, Issue 9, 2004

OVERHEAD CANOPY DESIGN

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We have described a modulation scheme using two or more base shapes arranged in accordance with an appropriate sequencing algorithm. One of the goals for canopy design was to utilize one optimized base shape to both satisfy an aesthetic goal and also reduce manufacturing costs. Using one optimal base shape, which is derived from the Shape Optimizer, requires that the shape be asymmetric. The remaining challenge is how to design the perimeter of this shape so that adjacent units tile together seamlessly and importantly in two or more orientations, thus forming an aperiodic arrangement over even extended surface areas.

Figure 1. A 1D Waveform Spline canopy. The asymmetric base shape is shown in bold. By changing the orientation, it is possible to increase the length of the diffusor to improve uniformity of diffusion.

1D Aperiodic Modulation

The simplest form of modulation is illustrated in Figure 1, in which a single asymmetrical diffuser base shape is flipped to double the repeat distance. If this base shape was arranged in a periodic fashion, grating lobes will arise. If, however, some of the periods are rotated, then the periodicity can be removed. In general this will improve the diffusion. A key to this type of modulation is to form a shape which is sufficiently asymmetrical, so that flipping the shape produces completely different scattering. A further complication is ensuring that neighboring diffusers tile together without discontinuity in surface displacement or gradient. By forming surfaces with zero end gradients and with the same surface displacement on both ends, it is possible to form a surface that will tile in any orientation. Then the architect can decide what pattern to form. More importantly, pseudorandom arrays enable diffusers of considerable extent to be created from small base shapes.

Figure 2 is a simple descriptive example of a patented aperiodic modulation of a simple asymmetric base shape, using optimal binary sequence encoding. The ordering of the base shape and its flipped version is called the modulation sequence. We also introduce the concept of zero-depth, zero-gradient tiling in this example. One can see that each end of the welled diffusor contains a half-well of zero depth. When the two units are tiled, a full-width well is produced to aid in visual continuity, producing pseudo-periodicity. Later we will describe a patented method to ensure tiling by constraining the perimeter gradient mathematically.

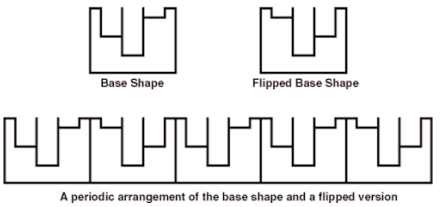

Figure 2. A simple asymmetric modulated diffusor using a base shape as a zero and its flipped shape as a one in an optimal binary sequence providing aperiodic modulation.

2D Optimized Shape Aperiodic Modulation

In its extreme, this modulation can result in a surface where the individual base shape is not clearly distinguishable. Figure 3 shows how a single period of an asymmetric, optimized, compound curved surface having the same symmetrical shape on each edge and zero gradient around the perimeter can form larger arrays, in this case a 4x4 array, in which the individual base shape loses its identity forming a new larger aperiodic pattern. The base shape surface can be tiled in any orientation and the use of one base shape reduces manufacturing costs.

Using a single asymmetrical base shape also gives designers control over the appearance. It can be made to look random or periodic, but remember that short repeat distances will result in worse sound diffusion.

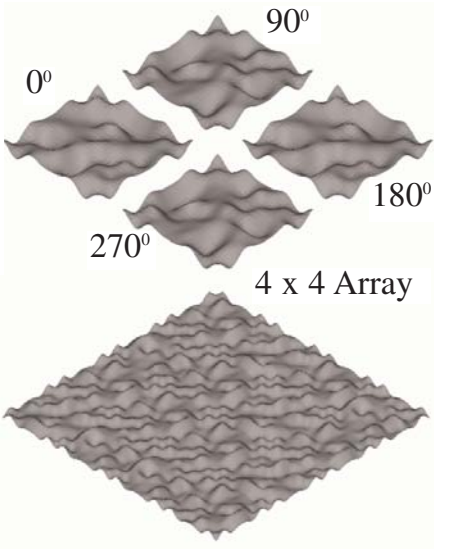

Figure 3. Top: Single asymmetric optimized base shape has zero gradient and equal displacement on all sides enabling the base shape to tile seamlessly in any orientation. Bottom: A 4x4 array shows how the base shape loses its identity forming a new aperiodic surface. Unlimited aperiodic shapes can be obtained by the orientation pattern.

In the next issue, we discuss how these approaches can be used to design optimized stage canopies.