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OVERHEAD CANOPY DESIGN

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There are many mathematical representations of curved surfaces which can be used. For example, it is possible to define a number of variable points on the surface shape and use a cubic spline algorithm in one plane, or a bicubic spline algorithm in two planes to form a smooth curved surface between the variable points. It is possible to construct a harmonic series not based on sinusoidal basis functions. Frequency and amplitude modulation processes can also be used to generate many different shapes. The essential principle is that one needs refinable parameters that define the shape. A typical boundary element mesh for a 2D Waveform Bicubic is shown in Figure 1.

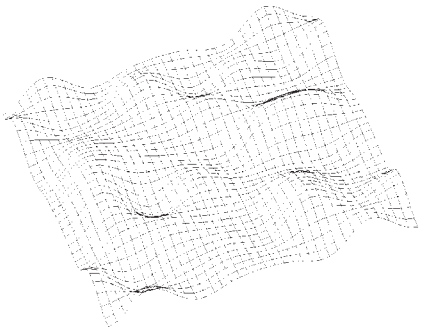

Figure 1. Boundary element mesh for a 2D Waveform Bicubic canopy element.

Problems sometimes arise when the best surface found by the computer does not meet the visual requirements of the architect. A curve was wanted, but the solutions produced were not quite what the designer originally envisaged. In addition, it is often necessary to ensure that the surface avoids other objects in the room, or has appropriate breaks to allow for lighting. In this case, non-acoustic constraints must be used in the optimization process to force the shape to meet visual and physical constraints. This can be done via a set of fuzzy coordinates through which the surface must pass. Figure 2 illustrates how such a system can be used to force a surface to pass through particular points. The error parameter in the optimization becomes a combination of the diffusion coefficient that measures the scattering quality and a penalty value that measures how close the surface is to the constraint points. This is often used to ensure that edges of diffusers meet walls as illustrated in Figure 2C. In addition, this technique can be used to ensure the following:

- cusps are not formed between adjacent periods of periodic diffusers;

- the left and right edges of diffusers are at the same displacement so that periodic diffusers edges will meet without a discontinuity,

- obstructions, such as pillars, are avoided.

While using such a constraint system is straightforward for physical problems, such as avoiding cusps, it is more problematic when trying to force the shape of the curve into the visual aesthetic demanded by the designer. Often during room design the interior designer has a definite idea about the general shape required for the diffuser - "we would like an S-shaped diffuser". Trying to come up with a suitable set of constraint points for this is possible, but involves some trial and error. For example, the points shown in Figure 2D will work some, but not all of the time. In addition, the constraint point system lacks elegance and will slow down the optimization process, by increasing the complexity of the error function surface to be searched. One partial solution is to use the spline construction, with linear constraints.

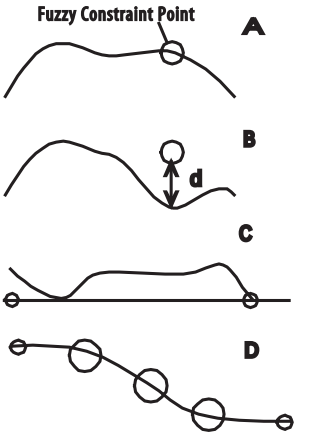

Figure 2. Use of fuzzy constraints to ensure that optimized curved canopies meet visual and physical constraints.
A. Surface passes through fuzzy constraint point, no penalty applied.
B. Surface misses fuzzy constraint point, penalty applied proporional to d.
C. Fuzzy constraints to ensure diffuser meets a wall or ceiling at edge
D. Fuzzy constraints to ensure an S-shape.

A superior system is one where the surface is designed from shape variables in such a way that the only surfaces generated are ones that satisfy the visual constraints. One way to do this is distortion. The architect supplies a base shape, and typical image processing distortion techniques are used to change the acoustical performance of the shape, while retaining the visual integrity. In the distorted pictures, it is still possible to recognize the picture as being a person; the rough visual appearance is maintained, yet radically different pictures are obtained.. To achieve this compression, modulation and warping techniques are used.

In the next issue, we discuss Aperiodic Modulation.