Cellular Tessellation is a small yet generous pavilion put on display as part of the Sydney Vivid Light festival in 2014. The project is both spatial and aesthetic, bringing the quality of architectural inhabitation and visceral experience to an urban festival which is typically limited to visual engagement.

The pavilion offers pedestrians an experience which is at once atmospheric and ephemeral—bathing occupants in the soft glow of concealed, Diaphanous light—whilst simultaneously precise and contextual—delineating a very clear relationship between the pavilion and the imminent landmarks of the Sydney Harbour Bridge and Utzon’s Sydney Opera House, which are framed by the overarching project geometry and a clear set of apertures, respectively.

Cellular Tessellation uses innovative computational form generation techniques to create and resolve the geometry and componentry of the pavilion. The project is fully parametric and digitally fabricated from flat sheet materials which are folded and
aggregated to create a shell comprised of 380 unique cells. Aluminium sandwich panels form the primary pavilion structure, which is akin to a rigid but non-hierarchical net of self-jigging elements. Each cell is infilled with acrylic sheet and clad with HDPE skin to house 200 lineal metres of LED diodes.

PROCESS DESCRIPTION
The algorithm designed for Cellular Tessellation hinges on four key concepts:

1. The ability to work on almost any surface (barring thresholds of the most extreme curvatures and curvature changes);
2. Adaptability without an overabundance of parameters (there are only 20 controllable parameters in 1071 nodes. Most solutions only require manipulating half of these);
3. Self-checking and repairing (collisions and aberrations are identified before moving to the fabrication state and repaired automatically where possible); and
4. Fabrication-ready (the output is sent directly to CAM software for tool-pathing and cutting with little or no post-processing).

The initial steps involve a sphere-packing routine which distributes equal size spheres over the base surface as tightly as possible without overlapping. The centre of these spheres, which are now evenly spaced across the surface in both U and V directions, can be then used to generate Voronoi cells that intersect the base surface at even increments. Before the cells are generated, the points are jittered in the X, Y, and Z directions by a small amount (+/- 60mm in this case) to generate more irregular forms, otherwise they will generate nearly perfect hexagonal cells. This method proved ideal as it solved some very common issues with the generation and fabrication of Voronoi cells: controlling the range of final cell sizes, the even distribution of cells over doubly-curved surfaces, and the prevention of very small segments and faces.

The next steps require a novel method of creating the aluminium composite panel structural frames and offsetting them equally in all directions. This is accomplished by isolating surface normal vectors common to two adjacent cells and projecting them onto planes generated at the cell centre. This is what allows the cell frames to negotiate doubly curved surfaces without collision, which only requires a single, uniform spacer thickness for all cell joints rather than custom spacers for all edge joins.

To manage the complexity of these operations, the algorithm has various error checking and correction methods for dealing with edge collapse, non-planar frame faces, and cell collisions, which were rare in practice but would be potentially catastrophic if not found before commencing fabrication. The use of these methods were also partially responsible for the very small (<2mm) working tolerance and resulted in a final structure that was within 0.5% of the computed limits in all dimensions of the physical outcome.
PROCESS DESCRIPTION

1. Base Surface (Variable)
2. Sphere Packing (Before Optimisation)
3. Sphere Packing (After Optimisation)
4. Voronoi Cell Generation From Sphere Centres
5. Cell Borders Offset And Projected To Planes
6. Inner Edges Projected At Random Intervals
7. 3D Cell Forms Lofted From Edges
8. Cells Trimmed On Outer Edges To Match Base Curvature
9. Final Structure With Exterior 'Scales'

The algorithm also provides various useful quantitative outputs such as overall structure dimensions, total area and volume calculations for the various materials, total cutting perimeters, and the total quantity of bolts, spacers, and LED lighting strips required to procure the project.

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Suppliers:
StudioWorkshop (floor fabrication), Oz Diodes (lights), Golden Sun Aluminium Panels (structure), All-Star Plastics (cladding), DMK Forest Products (floor), Konnect (fasteners), Gold Star Removalists (transport)

IMAGE CREDITS

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