Time-Form-Performance - Tessellation Design Laws

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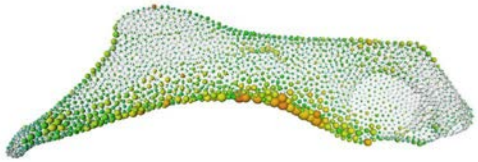
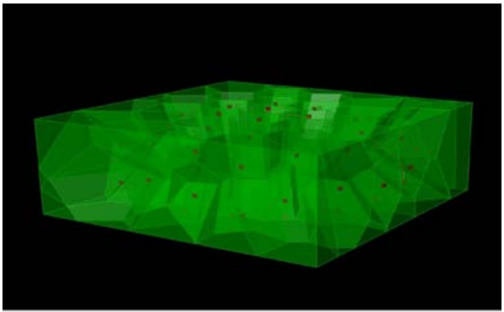
Abstract

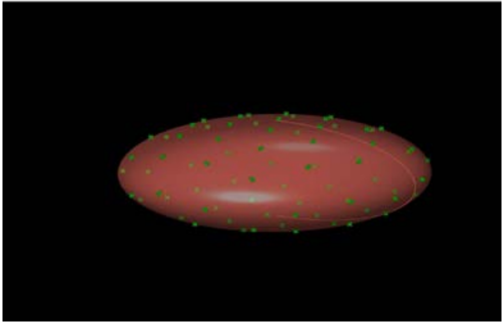
Tessellations are patterns covering surfaces (enclosed or not enclosed), with no significant gaps, minimal overlapping and interlocking. Familiar examples are the geometric tilings of pavements or floorings.

Tessellations are extremely common architectural motifs in Nature, attracting our attention for their huge variation and wide use, from building armors to tissues, tubes to wings). Observing examples in nature, with the help of engineering and material science tools, we can not only verify certain form-function relationships existing already in nature, but also use the form variations and boundary conditions in nature to explore other performances which haven’t yet been seen or evolved in nature.

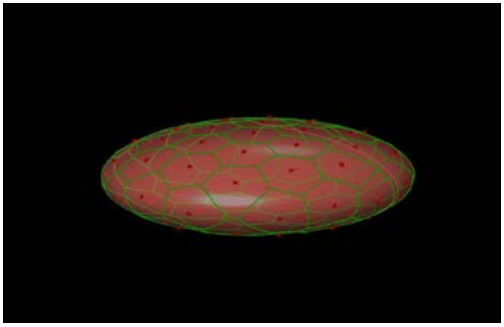


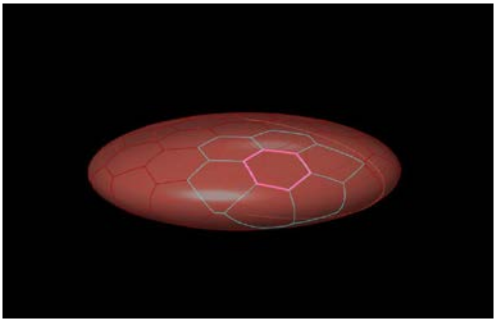
Tessellations in nature are not static, but rather are composite tissues that change with time, under dynamic loading regimes and as the organism and its tissues grow. However, building relationships between tiling patterns and mechanics in natural systems has been limited by our lack of understanding of the complexity of natural loading environments, growth and morphologies. To understand and frame





As we studied the cases in nature, tessellation patterns have been varying, however very often the growth patterns are connected with constraints. Combining the findings from the data analysis results of tessellated skeletal element in stingray, we can set up multilayer parameters for tessellation system building, either 2-dimensional plane or 3-dimensional surfaces. To achieve generative patterning, we could first use random points, then apply these points to the surface, evenly or randomly, in the end create Voronoi pattern at points via intersection with the surface. As a result, we will capture how the tessellation patterns have been developed by surface changing.





3. Form-Performance

The morphology, the patterns (arrangement) and connectivities enable some mechanical /optical /acoustical properties.

The static performance of tessellations is linked to how tessellations perform dynamically (e.g. how they manage/limit load frequencies, in-plane/out-plane displacements), suggesting that certain functions like active resonation/damping can be achieved through tailoring tessellation morphologies. From first stingray data, an algorithm of tessellation properties for target objects from different sizes and patterns can be summarized, allowing us to predict structural performance from tessellation parameters. If time allows, to further verify dynamic behaviors of tessellated systems, I would like to explore fabrication of tessellations as new tools for acoustics, predictive algorithms for tailored tessellation design. Or, if it is possible, we can make use of Machine learning to predict patterns from acoustic results or from acoustic mode shapes to predict patterns, verifying acoustic boundary conditions and their resultant acoustic field.