Constrained Planar Remeshing for Architecture

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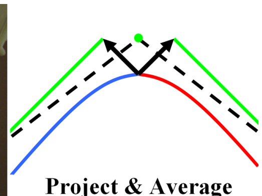
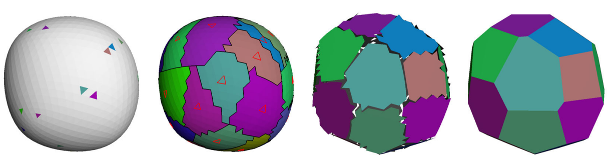
We are exploring an important class of architectural fabrication constraints: those associated with planar construction materials such as glass or plywood. Although glass can be bent into curved panels, flat planar sheets are more cost-effective to manufacture. With standard meshing techniques, designers are limited to triangular or quadrilateral primitives.

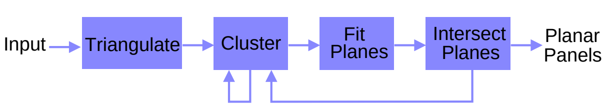
In the design study below, a Voronoi diagram is texture-mapped onto a 3D surface. A flexible rubber sheet was necessary to skin the non-planar cells. The designer wanted a planar remeshing tool that would generate *planar* meshings with similar patterns.



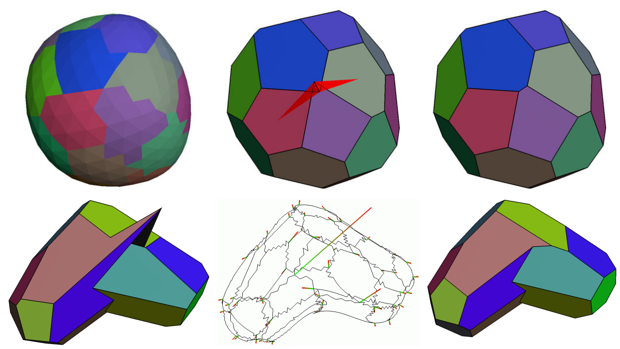
Cohen-Steiner et al. fit a pre-specified number of face clusters to a surface using Lloyd's relaxation. Planar proxies are assigned to these clusters and connected to create a polygonal mesh:



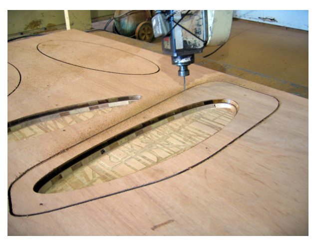
However, in their work the final polygon vertices are computed by *averaging* the projection of an original mesh vertex onto each proxy. Thus, facets that have more than three vertices will likely be non-planar. Unfortunately, the vertices from this remeshing cannot simply be moved such that all facets are planar. Instead we place vertices where neighboring planes intersect:

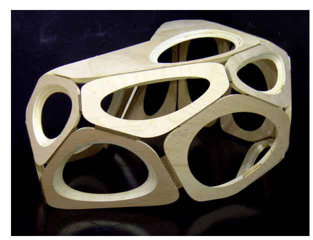


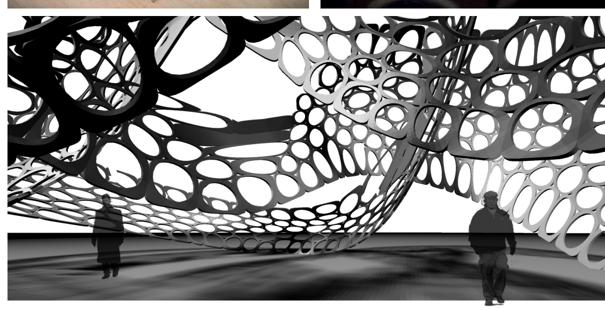
In this process the mesh may become inconsistent or degenerate. We detect and correct situations where an edge has "flipped" orientation or the intersection vertex "spikes" to infinity as shown below. The discontinuous nature of the solution space presents challenges for optimization because the neighborhood of a particular facet is not stable from iteration to iteration.



Using automated milling equipment, the panels are fabricated from planar plywood sheets and assembled to create a unique and inspiring outdoor sculpture. Our prototype tool has potential to impact not only architectural design, but also the engineering for general fabrication problems.







Acknowledgments

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References

Cohen-Steiner D., Alliez P., Desbrun M.: Variational Shape Approximation. ACM Transactions on Graphics 23, 3 (Aug. 2004), 905—914.