Designing asymptotic geodesic hybrid gridshells

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Certain types of freeform shells can be fabricated by bending originally flat and straight slats into curved structural elements. In their final position, one obtains a grid of surface strips forming the basis of an architectural structure. We present recent work on structures which are formed by three or four families of strips, arranged in a web.

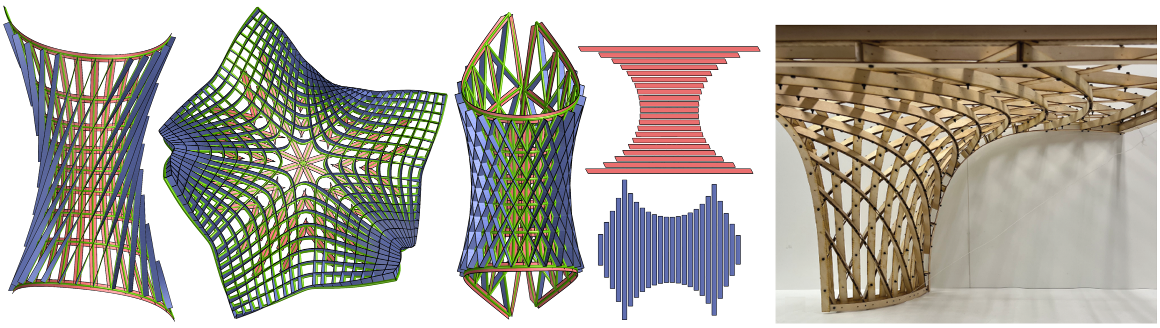
In their final curved position, the strips can be modeled as rectifying developable surfaces of their boundaries: Each tangent plane of a strip is orthogonal to the osculating plane at the corresponding boundary curve point. Thus, if a strip is placed orthogonal to an underlying reference surface S, it has to follow an asymptotic curve of S. If it is arranged tangentially to S, if follows a geodesic curve on S. Hence, these gridshells are designed from hybrid webs of *asymptotic* (A) and *geodesic* (G) curves on freeform surfaces.

Previous work focused mainly on a quadrilateral grid arrangement. If both families of strips are placed orthogonal to S, one obtains the asymptotic gridshells (AA) of Eike Schling [1]. Under the additional constraint of orthogonal node angles, the underlying surface is a minimal surface. The case (GG) of two tangential families of strips has recently been studied from the perpective of deployment from an arrangement of planar straight strips [2].

We present a computational workflow for the design of various types of hybrid asymptotic geodesic webs, using methods of discrete differential geometry, numerical optimization and a spline representation for the final strips. The following types are presented:

- *AGG* web: geodesic net (G-net) with one family of diagonal asymptotic curves (Fig.1-(a)).
- *AAG* web: asymptotic net (A-net) with one family of diagonal geodesic curves (Fig.1-(b)).
- *AAGG* web: A-net and G-net are diagonal to each other (Fig.1-(c)).

Physical models are made to verify the computational process and simulate the kinetic behavior during the erection process.



(a) AGG web (b) AAG web (c) AAGG web and unrolled strips (d) AAG timber model

Figure 1: Various types of hybrid asymptotic geodesic gridshells. Geodesic strips (red) are tangent to the underlying surface and asymptotic strips (blue) orthogonal to the surface. (c) one family of asymptotic and geodesic strips are also shown in their flat position. (d) A timber prototype of an AAG gridshell.

Joint work with: Helmut Pottmann, Eike Schling, Sebastian Hoyer.

References

[1] E. Schling, M. Kilian, H. Wang, D. Schikore, and H. Pottmann. Design and construction of curved support structures with repetitive parameters. *Advances in Architectural Geometry (AAG)*,140-165, 2018.

[2] S. Pillwein, and P. Musialski. Generalized deployable elastic geodesic grids. *ACM Transactions on Graphics (TOG)*, 40 (6), 2021.