Developable non-planar ngons in double curved surfaces

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Abstract

The field of architectural geometry has abundant literature on the rationalization of doubly curved surfaces for their buildability into planar elements such as triangles, quads and hexagons. The smoothness of the resulting mesh trade-off is between the density and the cost. We present a method for increasing the smoothness without raising the number of elements by means of a hex dominant mesh discretization composed of non-planar triangle star meshes, which get fully developable without gaps or overlaps, and whose inner central vertex, is close to the target surface. The method is based on the translation of the apex until a vanishing angle defect around it. The resulting apex is therefore a developable point making the star mesh a discrete flattenable cone with no cuts: just mountain and valley folds on a planar closed easy-to-manufacture polygonal region. We present the geometrical problem, and a general solution. We describe three implementation problems for doubly curved surfaces: based on a dynamic relaxation process, an iterative minimization process or an exact method. We discuss the convenience of the method for shells that can be built with folded material such as metal. Furthermore, we describe an enhancement of the method where mesh has torsion free nodes, thus assembly folded flaps can perform as planar beams.

References

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