Topology optimization of elastic geodesic gridshells

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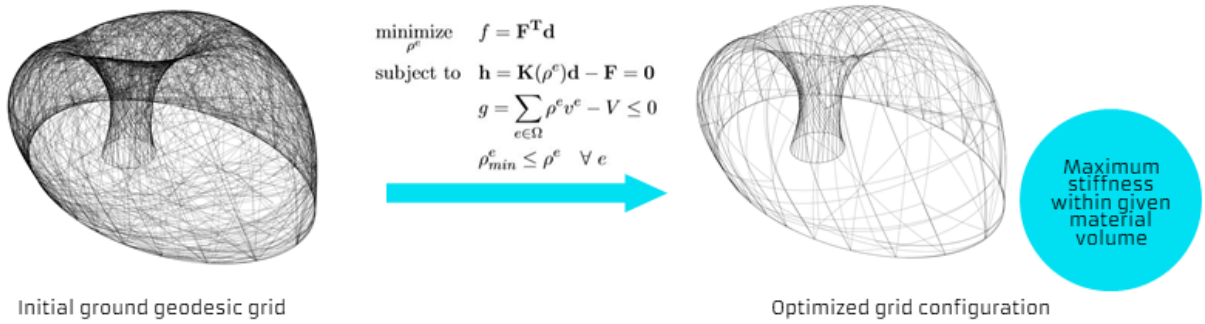

Abstract

Gridshells are highly efficient, lightweight structures which can cover long-spans with minimal use of material. However, there is an on-going discussion on the structural soundness of their layouts, which can be govern by geometry, aesthetics and other factors influencing their structural efficiency: "grid configuration is driven by visual conventions rather than a clear structural rationale. These factors often result in structural inefficiency and higher associated construction cost. [1]. Structural efficiency of gridshells become a part of multicriteria problems e.g. optimization of members orientation to minimize buckling and deflection [2] or topology and shape optimization under the stress, deflection and local buckling constraints [3].

This paper presents a new application of the topology optimization for determination of the grid configuration for the geodesic gridshell. Geodesic gridshells usually are composed of a grid of elastic members following geodesic of the freeform surface. The configuration of laths is govern by aesthetic, buildability or buckling analysis. This paper endeavors to implement and test topology optimization for maximum stiffness gridshell design within specified volume of material (minimum compliance problem). Implemented method uses the SIMP filter to eliminate members not contributing to the overall stiffness of the system. Presented method is tested on spherical surfaces of different height to span ratio to verify hypothesis about relationship dependence between curvature and density of the grid required to sustain desired gridshell efficiency.

This paper provides a new method for designing stiff geodesic gridshells govern by the structural efficiency and describes the relationship between the grid density and curvature of the surface. Presented optimization methodology for design of elastic timber gridshell with maximum stiffness can help in achieving higher bearing capacity and longer spans with minimized use of materials. As a consequence the presented method can bring novel applications of geodesic gridshells in the built environment.

References

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[3] J. N. Richardson, S. Adriaenssens, R. Filomeno Coelho, and P. Bouillard, "Discrete topology optimization," in *Shell Structures for Architecture: Form Finding and Optimization*, 2014, pp. 171–179.