A comparison amongst different shape control methods for shell optimization

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Summary

For shape optimization many different parameterization methods are currently used, all of them aim at both minimizing the number of design variables and increasing the control on the shape of the structure. This study compares two different approaches to parameterize the shell shape: the first is to define a geometric surface representation, like Bézier, the design variables are provided by the Cartesian coordinates of the control points. In the second approach a design velocity field using natural vibration modes of the initial geometry is defined. The objective surface geometry is determined by a scaled combination of the vibration modes. An optimization problem of shell structure is solved by these two approaches for comparison. The objective function is defined as total strain energy, and the gradient-based sequential quadratic programming algorithm is used. The goal of the research is to investigate the capabilities of the above methods trying to emphasize advantages and drawbacks of both of them.

Keywords: Shell, Shape Optimization, Structural Optimization, Design Velocity Field.

1. Introduction

A shell is a structure whose capability to bear loads is mostly ensured by its shape. The question is how to choose among infinite shapes the one that best matches the objective of membrane-oriented structural behaviour: the most efficient structure [1]. To this aim, the field of form-finding provides two main tools: the inverted hanging model [2]-[4] and the objective-function based optimization [6]-[11]. Both of them concern an inverse formulation of the problem where the unknown is just the shape of the shell: from a few given initial information, like span, height, loads, etc. the methods define the shape which satisfies the required structural behaviour. The extraordinary reliability and long-term performance of shell structures designed by means of the hanging model (experimental and numerical applications) prove its undiscussed efficiency. Nevertheless, this approach doesn't lack limits and disadvantages: it is almost impossible to take into account non-uniform load distributions, to look for the best thickness distribution, to consider other aspects not properly structural like costs, etc. In the light of these limits the structural optimization offers a more powerful tool to handle complicated form-finding problems.

Key point for good results in the structural optimization process is an adequate representation of the shell geometry. For structural optimization nowadays many different parameterization methods are currently used, all of them aim at both minimizing the number of design variables and increasing the control on the shape of the structure. This study compares two different approaches to parameterize the shell shape: the first is a general tool for surface representation based on the key idea of controlling Finite Element (FE) mesh through the position of few control nodes. This technique belongs to the wider field of Computer Aided Geometrical Design (CAGD). Among several approximating shape functions we implemented a triangular Bézier surface. The design variables are provided by the vertical Cartesian coordinate of the control points. The second approach consists in defining a design velocity field using several vibration modes of the initial geometry. The objective surface geometry is determined by summing up a linear combination of the

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