A general surface reconstruction method for post-processing of topology optimisation results

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ABSTRACT

In this work, a new semi-automatic surface reconstruction procedure is proposed. The main goal of the method is to reconstruct the boundary surface of a triangulation obtained as a result of a topology optimisation calculation. The reconstruction problem is articulated in two main phases: tessellation mapping and surface fitting. The first phase consists of retrieving a suitable map of the triangulation representing the boundary of the optimised topology. To this purpose, a segmentation of the original triangulation is performed and sub-domains (i.e. patches) are identified by means of a semi-automatic strategy. Then, a shape preserving parametrisation algorithm [1] is used on each patch in order to carry out the mapping and to preserve the real 3D shape of the boundary. The second phase deals with an original approach to the surface fitting problem: the problem is stated as a Constrained Non-Linear Programming Problem (CNLPP) by introducing a constraint on the maximum value of the Gaussian curvature of the boundary surface. In this study, the surface fitting problem is solved in the framework of Non-Uniform Rational Basis Splines (NURBS) surfaces. The main idea is to keep all the parameters defining the NURBS surface as design variables in order to state the surface fitting problem in the most general sense. Nevertheless, this fact implies two consequences of paramount importance, constituting just as many difficulties in solving the related CNLPP. Firstly, when the surface fitting problem is formulated by including the number of control points and the degrees of the basis functions among the unknowns, the overall number of design variables for the problem at hand is not fixed a-priori: hence, the resulting CNLPP is defined over a search space of variable dimension. Secondly, the numerical strategy chosen to face such a problem must be able to handle design variables of different nature and to optimise, at the same time, the dimension of the design domain as well as the value of each constitutive parameter of the NURBS surface. In order to overcome the two aforementioned issues, the surface fitting phase is composed of two optimisation steps. Firstly, the ERASMUS (EvolutionaRy Algorithm for optimiSation of ModUlar Systems) tool [2] optimises both the value and the number of design variables by means of a two-level Darwinian strategy, allowing the simultaneous evolution of individuals and species. Secondly, the optimum solution provided by ERASMUS constitutes the initial guess for the local gradient-based optimization, which aims at improving the accuracy of the fitting surface. The proposed method coupled with the NURBS-based SIMP algorithm [3], represents a valid solution for the semi-automatic post-processing of complex 3D shapes resulting from topology optimisation.

REFERENCES

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