On the formulation of dynamics problems in a NURBS-based Topology Optimisation Algorithm

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ABSTRACT

Topology Optimisation (TO) has experienced a period of intense growth in the last decades. Apart from mass/volume and stiffness of structures, an increasing interest in structural dynamics is arising. Particularly, eigen-frequencies and harmonic responses have been integrated in density-based TO algorithms (e.g. the SIMP method) [1]. However, dealing with these quantities implies circumventing some issues of numerical nature in TO, as "mode switching" and spurious modes. They are usually overcome through dedicated problem statements [1] and *ad hoc* penalisation schemes [2], respectively. The mutual penalisation scheme of stiffness and mass plays a fundamental role also in the minimisation of the steady state response of a structure subject to a time-harmonic load, especially when the driving frequency rises up and the convergence is affected by the interaction with the natural frequencies. In this case, the optimisation problem should be carefully addressed.

This work goes beyond the aforementioned aspects. When the TO is carried out, the consistence between the optimised configuration and the actual geometry reassembled in the CAD environment is crucial in order to use TO as an effective design tool. It is well-known that the SIMP method is an excellent and well-established tool to perform TO analyses but it provides a Finite Elements (FE) description of the topology. Concretely, this implies that a designer needs to post-process TO solutions to obtain the final topology and shape of the structure at hand. This phase is critical because it is subject to some arbitrary decisions and approximations introduced by the designer. In order to overcome these difficulties and to make this phase less dependent on the designer's experience, a NURBS-based algorithm has been developed in the SIMP framework [3,4]. The pseudo-density function describing the topology is represented through a NURBS surface or a NURBS hypersurface in case of 2D and 3D problems, respectively. Therefore, the new set of design variables is composed of the NURBS continuous parameters (the control points coordinates and weights) and the TO problems are reformulated accordingly. The intrinsic CAD-compatibility of NURBS entities allows for simplifying the post-processing phase after the TO run. As NURBS surfaces can be directly imported in CAD environment, retrieving the boundary of the actual, optimised, structure (and not the pixelised one) is a trivial task in 2D and facilities can be provided also for the 3D case. This approach has been successfully applied to the classic problem of compliance minimisation subject to an equality constraint on the volume. As a matter of fact, the NURBS formalism guarantees for a reduction of design variables and, thanks to the NURBS local support property, there is no need to define artificial filtering techniques to avoid ill-conditioning phenomena (checker-board effect). In this work, some dynamics problems are formulated in the NURBS framework and it is verified that analogue advantages can be observed. Some 2D and 3D benchmarks prove the effectiveness of the proposed method.

REFERENCES

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