EngOpt2018 - 6th International Conference on Engineering Optimization
Instituto Superior Técnico, Lisbon Portugal • 17-19 September, 2018
Editors: H.C. Rodrigues, J. Herskovits, C.M. Mota Soares, et al.

Abstract ID 1287

AN OPTIMIZATION APPROACH TO GENERATE ACCURATE AND EFFICIENT LOOKUP TABLES FOR ENGINEERING APPLICATIONS

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Keywords: Lookup table generation; Sequential optimal design; Unidirectional search; Interpolation accuracy; Engineering applications.

Abstract: Lookup tables are used to substitute time-consuming online calculations in many computational dynamics methods, as for instance for the railway wheel-rail interaction. In a wide number of engineering applications, the use of lookup tables can drastically reduce simulation times without greatly compromising accuracy, due to interpolation errors. The generation of a lookup table consists of pre-calculating the set of quantities that are required for the dynamic analysis, which covers the study domain. Thus, the computational cost of calculating these quantities is shifted from the numerical simulation to the generation of the lookup table, which is only performed once. During the dynamic analyses, the tables are interpolated to get all required parameters. The selection of the points that describe the lookup tables domain is of importance to ensure not only that the interpolated values are sufficiently accurate, but also that the number of points used is minimized. Currently, lookup tables are generated without involving measures to make them simpler or without error minimization in mind. To overcome this shortcoming, an optimization approach to automatically generate lookup tables with a prescribed accuracy is presented here. The points of a lookup table domain are grouped in a set of layers. The thicknesses of these layers represent distances between the points. To reach faster interpolations, the minimum size of the lookup table is identified, that is, the minimum number of points that define the lookup table domain. This objective consists of maximizing the layers thicknesses. In turn, to ensure specified accurate interpolations of the lookup table, the thicknesses of the layers are defined such that the deviation between interpolated and exact values at selected control points are kept under specified tolerances. Thus, the automatic lookup table generator tool developed in this work uses a sequential optimization strategy to design the layers of the lookup tables domain. To design the thicknesses of each layer, a dedicated optimization algorithm has been implemented. This algorithm uses a unidirectional search strategy that only considers the growth of the design variables. The optimization procedure reaches the optimal result when a layer cannot be thickened anymore without exceeding the specified tolerances for the interpolation errors. To demonstrate the performance of the proposed approach, lookup tables have been generated for known analytical functions, being adjusted the optimization options to reduce the time consumption. It is demonstrated that this work provides a reliable lookup tables generator to be applied in engineering applications.