Analysis-Suitable Parameterization for Isogeometric Simulation of Free-Form Structures: An Application to Curved Beams

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ABSTRACT

Focusing on analysis-aware modeling for structural static and vibration simulations of free-form curved beams, this work aims at constructing suitable isogeometric parameterizations to enhance analysis results for two different types of geometry inputs. Generally, the geometry (i.e., physical domain) in any kind of isogeometric analysis (IGA) can be obtained either by direct input from a commercial CAD software (e.g., Rhino) or by fitting a curve/surface/volume to a set of data points.

In the case of a direct geometry input, the parameterization is predefined in the imported spline functions and not guaranteed to be appropriate for IGA. It may cause ill-conditioned stiffness and mass matrices, and strongly affect the IGA results (considering that standard mesh refinement techniques are not always helpful). In such occasions, we suggest applying a “reparameterization” by means of a parametric transfer function (PTF) while keeping the geometry in its exact configuration (Hashemian et al. 2017; Hosseini et al. 2018). The main idea behind this transformation is to create a pseudo arc-length (almost linear) parameterization for the geometry.

On the other hand, when the geometry is given only in terms of input data points, which is the typical case in a number of applications (see, e.g., Morganti et al. 2015), in order to construct the geometry for IGA, the unknown control points need to be found by a curve fitting approach. In this way, the parameter selection and knot vector generation should be performed to construct the geometry. We propose that the combination of “chord-length” parameterization and “De Boor” knot placement will result in a suitable geometry construction for IGA.

For both cases, different numerical examples will be presented and the results (in terms of spectral approximation and L^2-norm errors of static deflection and eigenfrequencies) will be validated against “overkill” solutions computed with a commercial finite element software.

Keywords: analysis-suitable parameterization, reparameterization, free-form curved beams

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