The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Isogeometric Impact Simulations Under Large Rotations in Flexible Multibody Systems

Tobias Rückwald, Alexander Held and Robert Seifried

Institute of Mechanics and Ocean Engineering, Hamburg University of Technology,
Eißendorfer Straße 42, 21073 Hamburg, Germany,
{tobias.rueckwald, alexander.held, robert.seifried}@tuhh.de, tuhh.de/mum/home

Keywords: *IGA, Impact simulation, Floating frame of reference formulation*

Performing detailed impact simulations in flexible multibody systems, the flexible bodies in contact are usually described by reduced isoparametric finite element models. Thereby, for the precise calculation of the local deformations and contact forces, the exact representation of the geometries of the bodies is necessary. However, isoparametric finite elements involve the discretization of the geometry. Alternatively, the isogeometric analysis (IGA) can be applied to model the flexible bodies to preserve the exact geometry description in the finite element model. Additionally, higher frequency modes are represented more accurately in the IGA compared to isoparametric finite element models.

In literature, planar IGA models have been successfully used for impact simulations of flexible bodies in multibody systems. In this work, spatial problems are considered, which requires, among others, the extension of the contact detection algorithm. To cope with the large number of degrees of freedom of the 3D IGA modal in the impact simulation, the degrees of freedom of the IGA model are reduced using the Craig-Bampton component mode synthesis. Then the reduced model is incorporated into the multibody system using the floating frame of reference formulation to represent large rotations and translation. Care must be taken in the definition of kinematic constraints between the bodies, since the spatial IGA models are assembled from continuum elements, which only possess translational nodal degrees of freedom. To consider elastic rotations in the body kinematics, information on the nodal rotations are required. Therefore, interface nodes with rotational degrees of freedom are added to the IGA model in this work. Control points, which are near to the interface nodes, are constrained to their translation and rotation via nonlinear constraints. The nonlinear constraints are linearized with the Taylor expansion. This enables the inclusion of rotations in the reduced model and the more accurate description of the body kinematics and, hence, kinematical constraints.

The Newton's cradle serves as application example. The pendulums are modeled by 3D isogeometric spheres and are mounted by rigid rods. The first pendulum is initialized with an initial rotation. At the beginning of the time simulation, the integrator uses a relatively large step size. A contact detection checks whether two flexible bodies are approaching each other. If this is the case, the step size of the integrator is adjusted accordingly. The results show that efficient and accurate simulations of impacts with spatial IGA models in flexible multibody system are feasible.