Truncated Hierarchical NURBS for Local Refinement in Numerical Simulation of Rolling Tires

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ABSTRACT

All in all, the Finite Element Method (FEM) for tire analysis is a well-developed approach. However, after many years this method still has its drawbacks regarding geometry approximation: the construction of the mesh can be costly, time-consuming and it causes replacing curves with piecewise straight lines or parabolas. The incompleteness of FEM encouraged the scientific community to search for alternatives. Isogeometric Analysis (IGA) uses Non-Uniform Rational B-Splines (NURBS) as shape functions, which, in contrast to the in FEM employed polynomials, can represent a circle exactly. As a result, the exact geometry of a tire can be created using a minimal number of degrees of freedom.

Convenient local refinement is one of the most appealing structural analysis techniques available within the IGA framework. As presented in the literature, algorithms for one- and two-dimensional problems, where the subsequent layers of the computational mesh are created by standard h-refinement to form a multi-level nested basis for the numerical analysis, can be extended for the three-dimensional case [1]. Application of the global multilevel Bézier extraction operator allows the local refinement to be implemented into the standard FEM code [2]. Truncation of the support of basis functions allows the simplification of the numerical implementation. Furthermore, the introduced approach can be combined with the standard procedures of adaptive FEM for contact problems.

Main objective of this contribution is to apply the developed implementation to tire analysis. Thus, numerical simulations for rolling tires using IGA are shown. Complex cross-sections of tire-models are created using tools of CAD-software. An Arbitrary Lagrangian-Eulerian (ALE) formulation is used to describe the rolling phenomenon at steady state. In this formulation, the reference frame is neither attached to the material particles, nor fixed in space. Tire driving manoeuvres like acceleration, braking and free rolling are described in detail with special attention to the locally refined zone of tire-road contact. Important remarks and a discussion on the results obtained close this presentation.

REFERENCES

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