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Geometrically exact shells in flexible multibody dynamics

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ABSTRACT

The present work deals with the extension of contemporary finite element methods for nonlinear structural dynamics to the realm of flexible multibody dynamics. In particular, we aim at the incorporation of geometrically exact shell formulations into a multibody framework. Geometrically exact shell formulations are capable of dealing with finite deformation problems. In particular we focus on (i) a finite element discretization in space which inherits the frame-indifference of the nonlinear strain measures from the underlying continuous shell formulation, and (ii) a discretization in time which leads to an energy and momentum conserving scheme or an energy decaying variant thereof. In nonlinear structural dynamics energy-momentum schemes have proven to be well-suited for the stable numerical integration of large deformation problems.

We show that semi-discrete formulations emanating from the finite element discretization of geometrically exact shell theories can be regarded as discrete mechanical systems subject to holonomic constraints. Accordingly, the corresponding equations of motion can be written as differential-algebraic equations (DAEs) with index three. In particular, this viewpoint fits perfectly well into the framework of a rotationless description of rigid bodies [1] and geometrically exact beams [2]. Thus the DAEs provide a uniform framework for flexible multibody systems. Moreover, the DAEs turn out to be beneficial to the design of energy-momentum schemes [3-5]. The newly established DAE framework makes possible the design of energy-momentum schemes for flexible multibody systems comprising rigid bodies, geometrically exact beams and shells. In the case af pure shell dynamics our approach yields an energy-momentum scheme which is equivalent to that developed by Simo & Tarnow [6]. Representative numerical examples will demonstrate the capability of the proposed methodology.

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