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Unconditionally stable dynamic analysis of multi-patch Kirchhoff-Love shells in large deformations

Domenico Magisano[1*], Leonardo Leonetti[1] and Giovanni Garcea[1]

[1] Università della Calabria, 87036, Rende (Cosenza), Italy, domenico.magisano@unical.it

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One-step implicit time integration methods such as Newmark's schemes are only conditionally stable when used in large deformation analyses [1]. Simo and Tarnow proposed a simple method that guarantees unconditional stability by conserving the algorithmic energy in elastodynamics [2]. However, energy conservation is lost for other structural models as the Kirchhoff-Love theory, more efficient in the terms of spatial DOFs for thin shell problems, where the strain-displacement relationship is no longer quadratic. This work presents a numerical framework for long term dynamic simulations of structures made of multiple thin shells undergoing large deformations. The C1-continuity requirement of the Kirchhoff-Love theory is met in the interior of patches by cubic NURBS approximation functions, according to the isogeometric concept, with membrane locking avoided by patch-wise reduced integration [3]. A simple penalty approach for coupling adjacent patches, applicable to either smooth or non-smooth interfaces and either matching or non-matching discretizations is adopted to impose translational and rotational continuity [4]. The time-stepping scheme of Simo and Tarnow is generalized to achieve energy conservation for generally nonlinear strain measures and penalty coupling terms, like the nonlinear rotational one for thin shells. The method is based on a particular integral mean of the internal forces over the step, that includes Simo and Tarnow's method as a reduced quadrature rule, and has unconditional stability.

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