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Computational Geometry and the Analysis of Solids and Structures

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ABSTRACT

The concept of Isogeometric Analysis is described. Basis functions generated from NURBS (Non-Uniform Rational B-Splines) are employed to construct exact geometric models. For purposes of analysis, the basis is refined and/or its order elevated without changing the geometry or its parameterization. Analogues of finite-element, h-refinement and p- refinement schemes are presented, and a new, more efficient, higher-order concept, k-refinement, is introduced. Refinements are easily implemented and exact geometry is maintained at all levels without the necessity of subsequent communication with a CAD (Computer Aided Design) description. In the context of structural mechanics, it is established that the basis functions are complete with respect to affine transformations, meaning that all rigid body motions and constant strain states are exactly represented. Standard patch tests are likewise satisfied. Numerical examples exhibit optimal rates of convergence for linear elasticity problems and convergence to thin elastic shell solutions.

The concept of k-refinement is explored and shown to produce more accurate and robust results than standard finite elements for problems of structural vibrations. Through the use of nonlinear parameterizations, optical branches of frequency spectra are eliminated for k-refined meshes. Optical branches have been identified as contributors to Gibbs phenomena in wave propagation problems and the cause of rapid degradation of higher modes in p-method finite elements. A geometrically exact model of the NASA Aluminum Testbed Cylinder is constructed and frequencies and mode shapes are computed and shown to compare favorably with experimental results.

It is argued that Isogeometric Analysis is a powerful generalization of standard, polynomial-based, finite element analysis.

References

[1] T.J.R. Hughes, J.A. Cottrell, Y. Bazilevs. Isogeometric Analysis: CAD, finite elements, NURBS, edxact geometry, and mesh refinement. *Computer Methods in Applied Mechanics and Engineering*, 194:4135–4195, 2005.

[2] J.A. Cottrell, A. Reali, Y. Bazilevs, T.J.R. Hughes. Isogeometric Analysis of structural vibration. *Computer Methods in Applied Mechanics and Engineering*, in press, 2005. Also as an ICES report http://www.ices.utexas.edu.research/reports/2005/0527.pdf.