Multibody System Dynamics. Volume:30 Number: 2 Pages: 119-138. March 2013

Comparison between ANCF and B-spline surfaces

A. Mikkola, A.A. Shabana, C. Sanchez-Rebollo, J.R. Jiménez-Octavio

Abstract— This paper compares the descriptions of surfaces used in computational geometry (CG) methods and the finite element (FE) kinematics. Such a description is necessary for the successful Integration of Computer Aided Design and Analysis (I-CAD-A). B-spline surface geometry is defined using rigid recurrence formulas that employ the concept of the knot multiplicity to define the degree of continuity at the breakpoints. The knot multiplicity concept as well as the rigid recurrence formulas do not offer the flexibility provided by FE formulations. Furthermore, the concept of degrees of freedom is not considered in developing CG methods. Consequently, problems can be encountered in using the recurrence formulas to model certain types of joints. It is, therefore, important to adopt a FE method that is consistent with CG methods in order to be able to establish an efficient interface between CAD systems and analysis tools. The FE formulation used in this investigation for the surface description is the Absolute Nodal Coordinate Formulation (ANCF). It is shown in this paper that B-spline surfaces can be converted to ANCF thin plate finite elements without any geometric distortion. To this end, a linear transformation that defines the relationship between the B-spline surface control points and the ANCF position and gradient
vectors is developed. The resulting ANCF thin plate finite elements define a unique displacement and rotation field, and their geometry is invariant under an arbitrary rigid body rotations. The analysis presented in this paper clearly shows that all B-spline surfaces can be converted to ANCF meshes that have the same original CAD geometry. The converse is not true; that is, not all ANCF thin plate finite elements can be converted to B-spline surfaces. This sheds light on the flexibility and computational advantage that can be gained by the use of the FE method in the analysis as compared to the use of CG methods. The paper also shows how a B-spline surface can be converted systematically to a volume representation (full parameterization) using ANCF geometry.

Index Terms— Absolute nodal coordinate formulation; Isogeometric analysis; Thin plate elements; CAD; I-CAD-A

Citation:
Mikkola, A.; Shabana, A.A.; Sanchez-Rebollo, C.; Jiménez-Octavio, J.R.; "Comparison between ANCF and B-spline surfaces", Multibody System Dynamics, vol.30, no.2, pp.119-138. March, 2013.