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USNCCM99 is the official Congress of the U.S. Association for Computational Mechanics, USACM, an affiliate of the International Association for Computational Mechanics, IACM. The Congress is being held on the Boulder Campus of the University of Colorado, Wednesday-Friday, August 4-6, 1999, followed by a Short Course on Saturday, August 7, 1999.

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Computational Dynamics

Pål Bergan, Sanjay Govindjee, Robert L. Taylor and Nils-Erik Wiberg

We first propose a joint-based decomposition scheme which is natural for our purpose. The resulting model is best described in the form of differential-algebraic equations. Various numerical approaches in the literature - namely, local parameterization approach, stabilized constraint approach, perturbation approach and waveform relaxation method, are examined. Several unobtrusive algorithms which may well serve the gluing role are proposed / rediscovered. Numerical experiments are conducted and the merits of individual algorithms are commented.

Network-distributed computing may be perceived as a virtual parallel machine for engineering applications. numerous distributed models have been developed and deployed. The client-server paradigm [1] is adopted based on its obvious role in internet technology. An interface described in the CORBA IDL [2] will be used to illustrate the overall framework.

REFERENCES

[1] Alok Sinha, "Client - Server Computing", Communications of the ACM, 35(7) 77-98,1992.
[2] Sean Baker, "CORBA Distributed Objects," Addison-Wesley, 1997.

FLEXIBLE GEAR DYNAMICS MODELING IN MULTIBODY ANALYSIS

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ABSTRACT

A formulation for describing flexible gear pairs in three dimensional analysis of multibody systems is presented [1,2]. The set of holonomic and non-holonomic constraint eqautions that defines the behavior of gears is developed. The formulation is able to represent any kind of gears used in industry: spur gears, hypoid gears, racks, etc. All reaction forces due to gear engagement are accounted for. Teeth flexibility, clearance and mesh stiffness fluctuation are introduced in the model by relating deformation along the normal pressure line to the normal forces acting on teeth. Mesh stiffness is made dependent on the pitch displacement to account for stiffness fluctuation effects. It can be described either by a force/pitch displacement law or in terms of geometrical and material parameters following the recommendations of the ISO 6336 norm. Exact second order derivatives of all terms are calculated to allow computing vibration frequencies. Several examples of application are shown.

REFERENCES

[1] A. Cardona , "Flexible three dimensional gear modelling", Revue Europeene des Elements Finis, 4:663-691, 1995.
[2] A. Cardona , "Three dimensional gears modelling in multibody systems analysis", Int. J. Num. Meth. Engng., 40:357-381, 1995.

COUPLING BETWEEN RIGID MULTIBODY AND DEFORMABLE CONTINUA USING AN AUGMENTED LAGRANGIAN APPROACH.

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ABSTRACT

Many mechanical systems cannot be conveniently modeled as either rigid bodies or deformable ones but rather as a rigid-deformable mix. Standard analytical dynamics techniques fail to describe the continuum nature of the configuration space while the continuum mechanics formulation may introduce

unnecessary complexity to describe the motion of the rigid part. When dynamical effects are dominant, for instance with fast spinning devices, the continuum configuration space of the deformable body may be effectively discretized using modal analysis. In other instances where dynamical effects are less important, deformation may occur primarily as a result of applied and body forces. In such cases the finite element method has proven to be an effective way to discretize the configuration space of the deformable bodies. Although dynamical effects may not be important, quasi-static analyses of the deformable structure alone often fail due to the presence of possible rigid body modes in the system. The objective of this research is to develop a formalism to couple multibody systems in which inertial effects are not dominant with deformable continuum bodies that can undergo large displacements.

The rigid multibody dynamics are governed by the variational form of Lagrange's equation. Parameterization of the configuration space by generalized coordinates allows the equations of motion for multiple linkages or bodies pinned to a reference frame to be efficiently described.

The deformable body dynamics are governed by the variational form of the nonlinear elastodyanamics equations, which may also be derived from Lagrange's equation if the potential energy term is written to include energy contributions from stretching. The configuration space for the deformable domain is approximated with the finite element method. This approach allows for accurate representation of detailed geometry while providing stress and deformation information.

The deformable and rigid bodies are coupled through interfaces that are represented by constraint equations on the configuration space. For convenience, these equations take on the same spatial discretization as the deformable body at the interface.

The discretized constraint equations, along with the governing equations for the rigid body dynamics and elastodynamics, are coupled into a single system of nonlinear, semi-discrete equations using an augmented Lagrangian operator to ensure stability of the resulting numerical solution scheme. Newton's method is used to linearize the motion and constraint equations. These linearized equations, when combined with a time stepping algorithm such as Newmark's method, allows motion, velocity, and acceleration of the rigid and deformable bodies to be computed. The augmented Lagrange multipliers, part of the vector of unknowns, are simultaneously obtained and describe the generalized force necessary to enforce the constraints at the interface.

Examples from human locomotion biomechanics are discussed to illustrate the efficiency of the scheme to compute stresses in the joints during walking. Structures like the bones undergo large quasi-rigid motion with little deformation taking place. However, knowing the stresses developing in the joints during a physiological activity become important when studying the progression of degenerative diseases affecting a joint.

QUASI-STATIC MODE COMPENSATION FOR TRANSIENT DYNAMIC ANALYSIS AND DYNAMIC DATA RECOVERY

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ABSTRACT

Component mode synthesis (CMS) is a well established method for efficiently constructing models to analyze the dynamics of large complex structures, which are often described by separate component models. Most standard CMS methods currently employ static component modes, such as constraint modes, which originate from static compensation or the mode-acceleration methods. However, as the frequency bandwidth of interest increases, the constraint modes method's accuracy decreases.

Based on the quasi-static compensation technique of Ma and Hagiwara [1], a new CMS method has been developed by the authors [2, 3]. It combines the computational efficiency of the standard constraint modes approach with high accuracy typically seen in high-order and more expensive expansion methods via the use of a new class of component modes, namely the quasi-static modes (QSM). It has been shown that the new CMS method is suitable for eigenvalue problems associated with any bounded frequency range including mid-frequency band with both higher and lower normal modes omitted. In the present work, the new method is implemented into transient response analyses including stress