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Modeling of Coupled Rigid-Elastic Multibody Systems using DAE and ODE Formalisms

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We consider hybrid systems of both rigid and elastic bodies coupled into united structures using joints of various kinds. Typical way to simulate them is using differential-algebraic equations (DAE) that consist of differential equations of motion of separated rigid and elastic bodies as well as of algebraic equations of constraints between the bodies. DAE introduce additional difficulties into numerical investigations, e. g. problems of constraint violations. They can be successfully solved using different methods [1,2]. However it is possible in many cases to avoid DAE.

Equations of motion of a rigid body are Newton-Euler-Lagrange equations using any appropriate triplet of orientation angles or the four Euler-Rodriguez parameters.

Elastic bodies are simulated using any finite-element (FE) formulation (allowing large displacements), which can employ different sets of nodal coordinates, such as: rotation angles in *large rotation vector formulation*; finite slopes in *absolute nodal coordinate formulation* (ANCF) [3,4].

In the first approach, generalized coordinates for both rigid and elastic bodies are compatible and if we apply the well-known assembling procedure, we will obtain ODE only.

In the current paper we pay the main attention to the latter quite new approach.

When a rigid body is connected to an ANCF finite element without restrictions for relative angular orientation (revolute joint in planar case, spherical joint in spatial case), we can just use translational nodal coordinates of the FE and the orientation angles as the body generalized coordinates and apply the assembling procedure to obtain ODE.

If there are such restrictions (e. g. the body is rigidly attached to FE), we have two possibilities: 1) we implement constraint equations for the body and the FE and obtain DAE; 2) we develop new rigid-body elements that employ ANCF nodal slopes instead of rotation angles as generalized coordinates and further we can apply the assembling procedure again and obtain ODE [5,6].

References

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